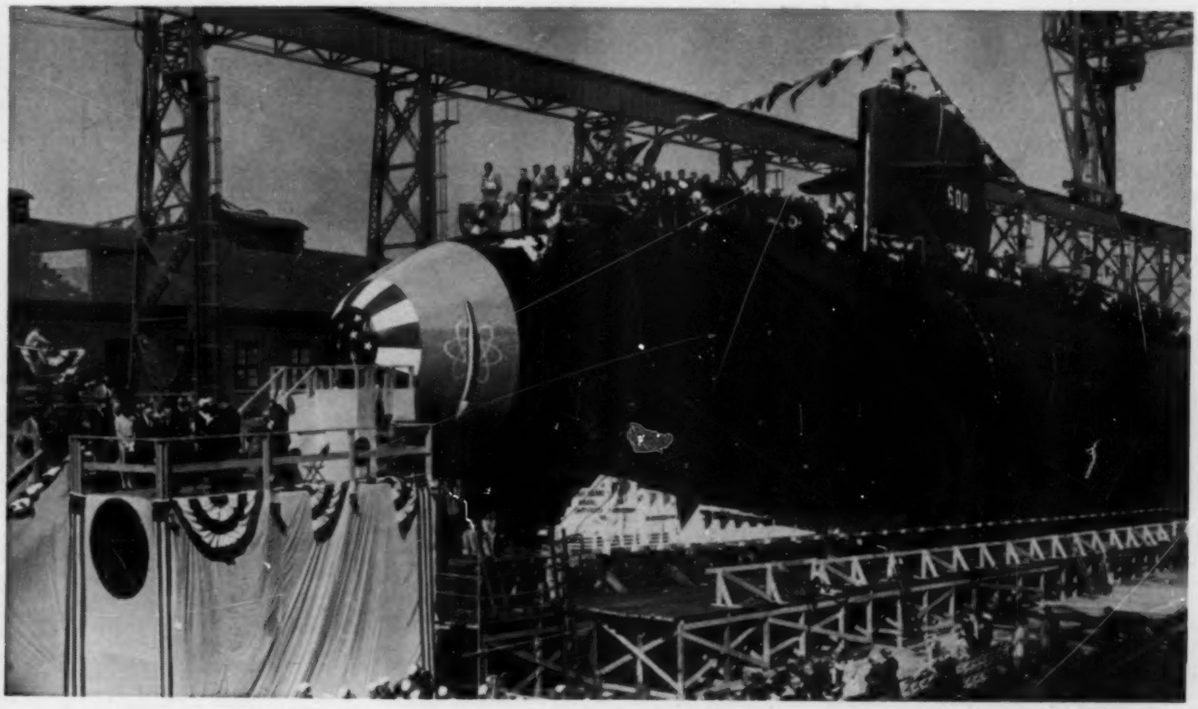
pilot issue

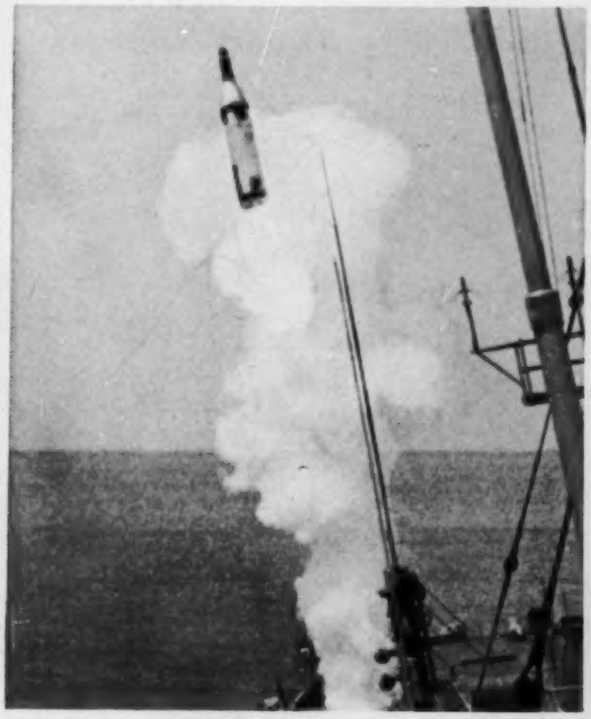
Undersea technology.

underwater engineering

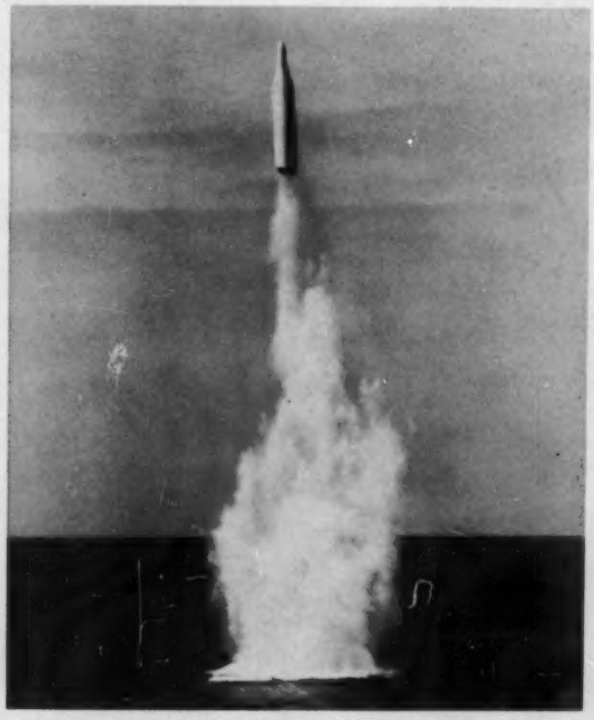

Creative
research,
practical
development*...
by
Bulova



USS Theodore Roosevelt, third of the Navy's new fleet of nuclear-powered, ballistic-missile submarines, was launched in October. Cruising submerged for indefinite periods, it will be manned by two interchangeable crews...carry 16 POLARIS missiles.



Fired from a surface ship, a POLARIS test missile ignites automatically after being blown by air pressure from a below-deck launching tube. Navy will use similar tubes in FBM subs. In all, over 30 test missiles have been launched.



Operational in late 1960, the Navy's Fleet Ballistic Missile system will give America a new dimension in deterrence. Each FBM submarine will be a self-contained *mobile* missile base —ready to launch its POLARIS missiles at a moment's notice.

LOCKHEED

MISSILES AND SPACE DIVISION

MISSILE RESEARCH & DEVELOPMENT • BALLISTIC MISSILE SYSTEMS MANAGEMENT
ROCKETRY • ULTRASONIC AERODYNAMICS • SPACE INVESTIGATIONS • NUCLEAR PHYSICS
ADVANCED ELECTRONICS • HIGH-SPEED AUTOMATIC DATA REDUCTION
SATELLITES • RAMJET PROPULSION TESTING

Let's take a look at submarines

It's one thing to peer through a sight at an enemy submarine. And it's quite another to be peered at.

At the Mechanical Division of General Mills, we help the U. S. Navy take both views into consideration. We build weapons to destroy enemy submarines should we ever be attacked. These are the latest in a series of ordnance items we have been producing for the Navy since before World War II. And, we build radar antennas and related equipment to help our submarines to defend themselves.

Possibly you too can benefit from our defense production experience. The Navy is only one of our military customers. For the Air Force and Army we make or have made bombsights and gunsights, missile guidance and control equipment, search and surveillance systems plus other electro-mechanical and electronic subsystems. We'd like to tell you more about our service to industry and the military. Our unified team can handle research, engineering or manufacturing—or the entire package. Write Dept. AA-10, Mechanical Division of General Mills, 1620 Central Ave., Mpls. 13, Minn.

MECHANICAL DIVISION

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General Mills

underwater
engineering

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features

cover

New timing devices have been developed for Navy frogmen by Bulova Watch Company. Special feature article will appear in the May/June issue of Underwater Engineering Magazine.

★ ★

circulation & subscription

NOTE—Underwater Engineering circulation is executed on a controlled unpaid basis. Engineering and management personnel actively engaged in the areas of undersea warfare and oceanography are considered qualified applicants. Use the self-addressed post card in this issue or write to Circulation Dept., 2775 So. Moreland Blvd., Cleveland 20, Ohio.

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editorial

By VAdm. C. B. Momsen (Ret.)

As man's landlocked mineral resources begin to fail him, research in the mining of seawater will become more than academic, and development will become imperative. Another area of proven profit lies just beneath this watery wealth—the ocean bottom, deep in the sediment of centuries, rich with the accretion of the seas.

Beneath these abundant bottom lands lie additional sources of wealth barely touched. Mining sulfur in relatively shallow water has become a profitable industry, and it is estimated that our continental shelves could yield some 20-billion barrels of crude oil and 150-billion cubic feet of natural gas, using present practices. In all, 400-billion barrels of oil, about a third of all that remaining on earth, waits below the sea bed. Improved engineering skills soon will enable us to work in deep water and tap a great deal of this reserve.

Can it be that, as with Sputnik which triggered an hysterical effort on our part to catch up in the space race, we have been awakened to the urgency of greater study of the oceans by reports of Russian advances in oceanography? Or are frequent warnings of scientists that our hydrocarbon fuel supply is dwindling and food production inadequate to meet anticipated demands finally achieving some results in the laboratories and factories of industry?

Whatever the cause, the effects upon business and the military will be far-reaching. Present research in commercial exploitation of oceanic resources soon may lead to a significant source of power, food, and minerals —literally "oceans" of profit opportunities.

It is the "interface," that area "between wind and water," that man knows best, and for centuries he has plied it with his vessels, battled its vastness, and finally subdued it. Still the sea is one of the most incommodious roads he could have chosen to travel. Its surface boils with continuous motion, driven by winds, currents, and tides. At last, with technological progress, the magnitude of these forces can be reckoned, and put to do a share of man's work.

Russia already has an operational fleet of some 500 submarines, which puts an added emphasis on charting the seas. Scientists warn that our efforts to conquer the oceans must be re-doubled within the next 10 years or we will be lagging far behind. Aside from the military aspects of underwater transport, however, there is increasing hope that research may remedy the difficulties of present-day marine commerce.

Recent successes with nuclear submarines may pave the way to commercially successful undersea shipping of passengers and cargo, both liquid and dry, in the near future. The initial cost of a private nuclear fleet would be higher because of the power plant, but fuel savings would be great, it would be faster, and completely escape the delays and dangers of rough weather which hinder surface transportation.

Trans-polar trade is another distinct advantage of undersea commerce; travel between Japan and Britain, for example, could be shortened by 5,000 miles by the use of submarine merchant ships.

Our sky-probing is certainly more advanced than these quiet probings into the mysteries of the seas; we may reach the moon before we learn how deep the ocean is. Yet the commercial potential of the seas far outweighs that of space.

Willard Bascom, technical director of the AMSOC committee and long a spokesman for the commercial exploitation of ocean resources, indicts industry for the paucity of oceanographic research:

"Most businessmen are reluctant to spend enough money to make even the most tentative survey of business opportunities in the ocean. They expect to send a man to Scripps of Woods Hole for a day and have him come home with tales of great riches to be gained in a few months. Industry has not made even a minimum effort to learn about the problems and possible profits of the oceans.

"What the oceans need is a genuine old-fashioned entrepreneur."

Neptune, the mythological ruler of the deep, had all the waters of the earth as his domain. Triton, his son, was assigned the vital task of communicating his father's commands to subordinates in all parts of the ocean.

The U. S. Navy has need of a counterpart for Triton. RCA is now assisting in this role through development of a communication link to our new nuclear powered Polaris-carrying submarines, anywhere on the seven seas.

RCA, in addition to its Polaris developments, is also working on many new Undersea Warfare systems such as detection, classification and destruction of enemy submarines as well as coordination of our friendly air, surface, and subsurface effort.

RCA Tmk(s) ®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, NEW JERSEY

capital report

SOVIETS PUSH NUCLEAR SUBMARINE PROGRAM

First nuclear submarine built in the Soviet Union is now undergoing operational tests, according to unofficial sources here. It is believed that the Russians now have a minimum of three additional submarines under construction and that production of conventional, diesel-powered submarines is phasing out. In a report to the House of Commons yesterday, Charles Ian Orr-Ewing, Civil Lord of the Admiralty, testified that the Soviet Union submarine fleet now totals 500 vessels. He said nine Soviet submarines had been handed over to the United Arab Republic, and an additional eight and a modern submarine tender were based in Communist Albania.

Little is known of the Russian submarine production capability. Some Navy sources said it must be assumed that the Russians are as capable as the Germans. At the end of 1941 the Germans built 15 diesel-powered submarines per month.

U.S. Navy is expected to boost its Polaris missile-submarine building program upwards of $1 billion next year and $2 billion to the still unwritten budget for fiscal 1962. First full-fledged Polaris shoot is scheduled for March 29.

* * *

RYAN ELECTRONICS AWARDED $5.9 MILLION CONTRACT FOR HELICOPTER NAVIGATORS

A new contract for $5,914,000 has been awarded to Ryan Electronics, division of Ryan Aeronautical Co., by the Bureau of Naval Weapons, Washington, D.C. This letter contract covers initial procurement of AN/APN-130 doppler radar navigation sets, spares, support equipment, and engineering support items.

The Ryan navigation sets will be supplied for use in the Navy's latest rotary wing anti-submarine aircraft, including Sikorsky HSS-2 amphibious helicopters and Kaman HU2K-1 type helicopters. Deliveries are scheduled to start in April of this year and continue until September, 1961.

The AN/APN-130 is an advanced self-contained doppler airborne ground velocity indicator that enables helicopters to automatically achieve and maintain sustained precision hovering under all weather conditions—essential to the use of sonar techniques for the detection of enemy submarines.

Engineering under the new contract will be done at the Ryan Electronics Engineering research center at Kearny Mesa, San Diego, and production will be accomplished at the division's manufacturing plant in Torrance, Calif.

* * *

NAVY TO PUBLISH NEW MAGAZINE FOR ENGINEERS

"The Navy Civil Engineer" is the name of a new magazine published by Navy's Bureau of Yards and Docks for the Civil Engineer Corps and its Public Works Departments of Shore Installations. The publication, edited by Carl M. Mann, will be distributed on an internal basis to Navy shore installation personnel, and to key personnel in other DOD activities. Volume 1, No. 1 is expected to be off the presses soon.

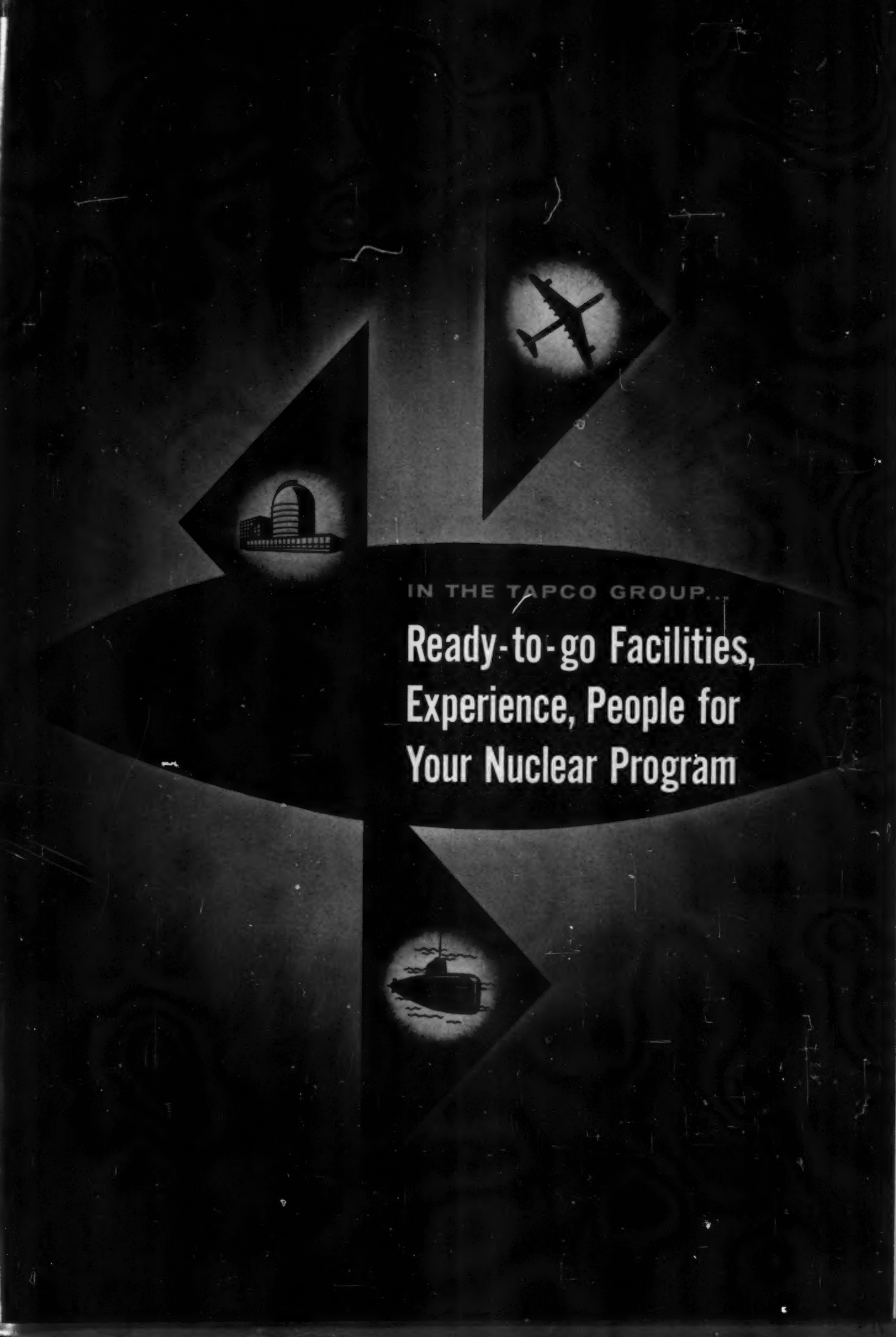
* * *

THIOKOL GETS CONTRACT FOR DEVELOPMENT OF ADDITIONAL PRE-PACKAGED LIQUID ENGINE

A $2 million contract for development of a pre-packaged liquid rocket engine has been signed by Navy's Bureau of Naval Weapons and the Thiokol Chemical Corporation. The "GUARDIAN III" contract covers complete development of an engine with over twice the power of the "GUARDIAN II" engine, now in production along with the "GUARDIAN I" engine at the Reaction Motors Division Production Plant in Bristol, Pa.

According to Thiokol engineers, this new contract will further demonstrate the scalability of the pre-packaged liquid engine. The design principles of this type of powerplant have been established as the basis for an extensive family of liquid propellant rocket engines for use in a variety of missile applications. Like its predecessors, the new "GUARDIAN III" is an integral unit containing tankage, thrust chamber, all necessary components, and preloaded with propellants before it leaves the factory. It is designed to be received in the field fully ready to be fired upon installation in the missile.

Under the terms of this contract, the design, development, Preliminary Flight Rating Tests, and Qualification Test of the "GUARDIAN III" engine are ex-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Ready-to-go Facilities,
Experience, People for
Your Nuclear Program

AT TAPCO...

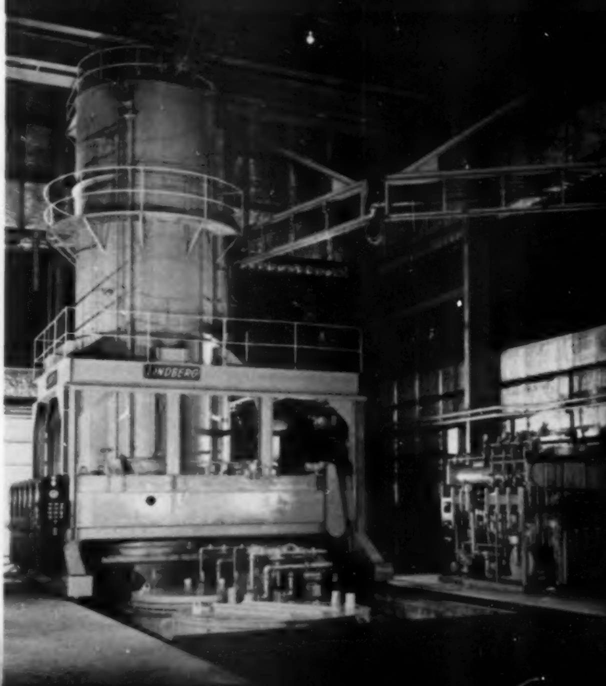
3,000,000 square feet of facilities, 17,000 manufacturing and inspection tools to handle a wide range of Nuclear Projects

Reactor core barrels and similar reactor parts can be turned, bored, and faced on this 144"-diameter Betts Vertical Boring Mill.

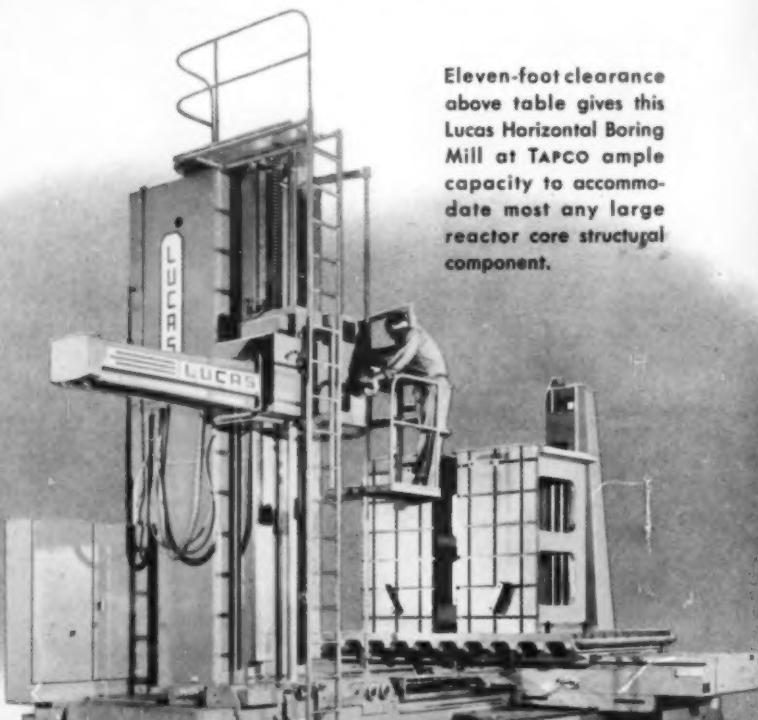
Whether your nuclear project requires components as large as core structurals or parts as small as control-rod drive mechanism gears, the TAPCO GROUP is equipped to do the job . . . to highest precision, and on schedule.

No shop is better equipped with modern machine tools to produce fuel element hardware, control-rod drive mechanisms, core structurals, special pumps, valves and blowers, and electronic control systems. Extensive test and quality control facilities make sure we have met your specifications before delivery.

Complete research facilities at TAPCO can investigate new metals and new uses of the conventional metals for reactor applications. Special test facilities at Roanoke, Virginia, are equipped for unusual and hazardous-condition testing and research.



Reactor components up to six feet in diameter by 22 feet long may be heat treated in this Lindberg Gantry Controlled Atmosphere Furnace now in the process of installation at TAPCO.



Eleven-foot clearance above table gives this Lucas Horizontal Boring Mill at TAPCO ample capacity to accommodate most any large reactor core structural component.

TRW

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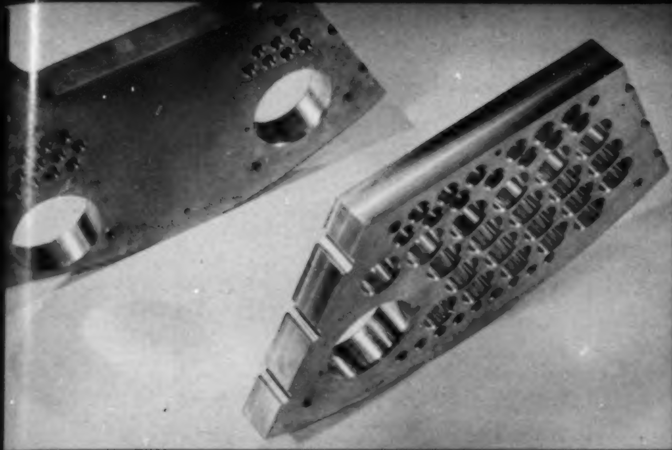
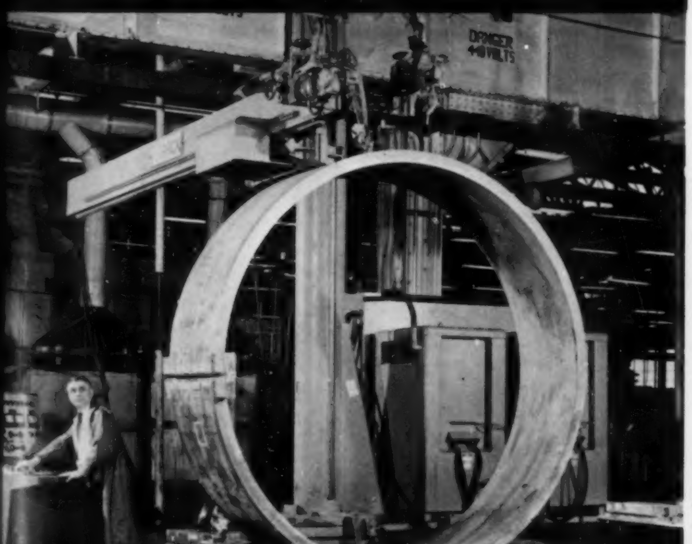


Sample basket segments manufactured by the TAPCO GROUP for the Westinghouse Testing Reactor.

One of TAPCO's skilled machinists checking precision milling operations on a reactor bottom core plate.

A battery of optical jig mills in controlled atmosphere rooms at TAPCO is available for high-precision special production runs on machining nuclear parts, as well as for the accurate inspection of dimensions and contours.



Positioning heavy stainless steel ring for submerged arc welding operation on a Herrick 10 x 12-foot automatic welder. One of many precision welding machines at the TAPCO plant.

FROM THE TAPCO GROUP...

Experience in the engineering and production of components for the Nuclear Industry

This experience has been acquired through participation in a wide variety of nuclear projects for many prominent customers in the atomic field.

To meet the requirements of all such nuclear work, the TAPCO GROUP has successfully applied its vast experience to the development of unusual fabricating techniques, the use of metals and alloys in extreme environments, and the design of precision electronic and pneumatic control devices.

CAPABILITIES

Core Structural Components

- Core Barrels and Flanges
- Grid Plates and Bottom Support Plates
- Module Boxes
- Ports, Housings, Nozzles and Shrouds
- Fuel Casks and Refueling Devices

Reactor Control System

- Flux Scanning Devices
- Temperature and Pressure Measuring Devices
- Control Consoles
- Custom Amplifiers and Rack Assemblies
- Control Rod Position Indicators

Control Rod Drive Mechanisms

Special-Purpose Blowers, Compressors and Turbines

- Helium
- Nitrogen
- Freon
- Carbon Dioxide
- Air

Special-Purpose Pumps, Valves, Seals and Fittings

- Sodium and Potassium
- Bismuth-uranium
- Heavy Water
- Organic Fluids

Reactor Test Loops

Unconventional Heat Sources and Auxiliary Power Units

pected to be completed in less than one-third of the time normally devoted to the development of a new rocket engine.

The proposed "GUARDIAN III" pre-packaged liquid engine is a much larger version of its predecessor, the "GUARDIAN II" engine, currently undergoing final flight tests at the Naval Missile Center, Point Mugu, California. Thiokol's Reaction Motors Division has already demonstrated the feasibility of large pre-packaged liquid engines by successfully firing a 50,000 lb. thrust pre-packaged liquid engine.

* * *

OCEANOGRAPHIC OBSERVATIONS AT IGY WILKES STATION

During the 1957-58 IGY scientific program in Antarctica, studies were conducted at US-IGY Wilkes Station on floating ice, currents, tides, and bottom sediments. Some hydrographic and bottom-topography survey work was also accomplished. Wilkes Station is situated at 66°15′25″S, 110°31′39″E, in the Windmill Islands on the Budd Coast of East Antarctica. The station is at the western end of Clark Island.

The condition and extent of fast ice and floes were observed daily from the aurora tower and, on all except days of extremely poor visibility, movements of ice were photographed with a 16-mm, time-lapse motion picture camera from the same location. A portable tide gage was installed and continuously operated for slightly longer than one complete lunar cycle in the autumn and was again placed in operation in the spring for approximately two months. A series of ten bottom samples were obtained, extending from the shore to deep water in Newcomb Bay. Survey work was accomplished in which the position and orientation of Clark Island and the northern islands were tied in with a point on Holl Island accurately determined by astronomic techniques.

* * *

BUWEAP AWARDS $25.2 MILLION TERRIER CONTRACT

Convair Division of General Dynamics Corp. has been awarded a $25,200,000 contract from the Bureau of Naval Weapons for additional production of advanced Terrier guided missiles. The antiaircraft Terrier weapon will be produced at the U.S. Naval Industrial Reserve Ordnance Plant, operated for the Navy by Convair's Pomona division.

The new version of the Terrier has greatly improved effectiveness against low-flying aircraft and multiple targets, Convair reports. It will extend the fleet's present antiaircraft capability to provide defense against surface targets and land installations. The USS Dewey will be the first ship to be armed with advanced Terrier.

* * *

ASW COMMITTEE'S REPORT SUBMITTED TO NAVY

The National Security Industrial Association's Anti-submarine Warfare Advisory Committee has submitted to the Navy a 3-volume report on the current status of our anti-submarine programs. The report is a result of some 45 high-level conferences and meetings held over the past 16 months. More than 300 representatives from industry have participated in forming the report.

The first volume of the report encompasses a chronology of the committee's activities, gives general recommendations on policy and management, and points out the excellent cooperation existing between the Navy and the participating industries. The second volume names the committee members and describes their competence to participate in the project. The third volume, which is classified "SECRET" gives specific recommendations on hardware, weapon systems, research and development, and feasibility studies.

A total of 85 programs is recommended in the report. The NSIA Anti-submarine Warfare Advisory Committee is headed by Fordyce Tuttle, Scientific Advisor to Management, Eastman Kodak Company. The committee is conducting its work under the auspices of Adm. Arleigh A. Burke, USN, Chief of Naval Operations. Direct and continuous liaison is maintained with ASW Readiness Executive (OPNAV 001) Rear Adm. H. A. Yeager.

* * *

BENDIX DROPS "AVIATION"

Bendix Aviation Corporation stockholders have voted to adopt a new name—"The Bendix Corporation." The name change is planned to be put into effect about June 1 according to company spokesmen.

Bendix President Malcolm P. Ferguson had this to say about the choice of a new title: "The Corporation is engaged in the manufacture and sale not only of aviation products but of a great number of automotive, electronic, nuclear, missile and space, marine, machine tool and industrial products. The diversity of these products is continually expanding, so it has become increasingly important for our Corporation not to convey the impression that its products and skills are limited to the field of aviation."

nautical notes

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By Peer Fossen

The first firing of a POLARIS missile using all system components integrated will take place in the latter part of this month from the test missile ship *Observation Island.*

* * *

Marine Systems Group of Minneapolis-Honeywell Aeronautical Division has started work on an electrically suspended gyro for the POLARIS program. The new gyro will eliminate friction. Immediate goal is incorporating the new gyro in SINS (Ships Inertial Navigation System).

* * *

A visit aboard the USSR Oceanographic Ship LOMONSOV in New York during the fall meeting of the International Oceanographic Congress held at the United Nations building revealed how anxious the Soviet scientists were to show all their facilities, display results, specimens and navigation tracks and soundings. Nothing was held back except access to the sonar equipment room ("the man with the key is ashore"), their facilities, the knowledge of their many scientists aboard and the size of their effort were most impressive. One of the leading scientists on board, a Soviet Doctor of Oceanography, was a woman.

* * *

Reynolds Aluminum Co. expects their experimental all-aluminum hull submarine ALUMINAUT to be completed early next year. This project, under Rear Admiral Day, USN (Ret), Reynolds executive, may prove the feasibility of aluminum for submarines, saving weight. But many ship experts disagree—so this is likely to become a controversial issue. ALUMINAUT is expected to dive 15,000 feet.

* * *

SARGO surfaced 25 February after a record-breaking 30 days under the Polar Ice. NAUTILUS made two trips of 12 days each and SKATE 5 days. SARGO proved the military value of the trips by poking up through the ice five times, as SKATE had done. Missiles can thus be fired from polar regions by POLARIS type subs. SARGO arrived in Pearl Harbor, her home port, earlier this month.

* * *

The Navy purchased the bathyscaphe TRIESTE from the Piccards in 1958 for $205,000 and paid $150,000 for a new sphere attachment. In the contract was the stipulation "Piccard will act as instructor pilot and actually participate in dives." A post-dive check of the depth recording equipment of the TRIESTE revealed a 2,000 foot error in the recorder. The adjusted depth obtained was 35,800 feet instead of 37,800 feet first reported. TRIESTE will make one more dive in the present scheduled series with Dr. Reichnetzer and one other man slated to make it.

* * *

A reliable, long-range IFF system still appears to be an unsolved problem of greatest importance. Despite information our own forces may get on the location of our friendly submarines "we need an IFF device similar to that in use in aircraft identification," Navy men said.

* * *

Vice Admiral H. E. Sears, USN (Ret), Executive Director of Armed Forces Management Assn. has informed Adm. Raborn, POLARIS director, that numerous industrial concerns are interested in the POLARIS program "vertical management" methods. The amazing results obtained by Adm. Raborn's group of 539 officers and men (175 with decision-making powers) directing nearly 6,000 contractors and subcontractors and completing jobs ahead of schedule has won the applause of veterans in industrial management.

* * *

Project TENOC, the ten year oceanographic research program proposed by the National Academy of Science *Underseas Advisory Committee* has been endorsed by Admiral Burke.

Problem: HYDROSPACE

Hydrospace — concept of space in ocean, motion through an opaque medium — offers a complex of challenge unique in engineering. To solve this tri-dimensional riddle, Raytheon's Submarine Signal offers an equally unique concept — industry's first ASW CENTER.

Now under construction, the Center will be a *single* activity devoted to research, development and production of detection, navigation, communications and fire control equipments.

Prime programs concern pro and anti-submarine warfare, advanced systems studies, oceanography. Product vehicles are: submarines; surface and hydrofoil ships; air and underwater drones; missiles; helicopters. Pressure, opacity, dense packaging necessitate the highest level of technology.

For information on select staff openings in several technical specialties, write: Mr. Donald H. Sweet, Executive & Engineering Placement, Raytheon Company, 624 E Worcester Road, Framingham, Massachusetts (suburban Boston).

RAYTHEON

EXCELLENCE IN ELECTRONICS

SUBMARINE SIGNAL

EQUIPMENT DIVISION

navy insider

By RAdm. P. D. Gallery, USN (Ret.)

.Navy will announce shortly the amount paid by Argentina for U.S. help investigating that reported "sub" in Argentine waters. Depth charges, sonobuoys, aircraft flares, torpedoes, electronic test equipment and spares were furnished. U.S. naval personnel acted only as advisors, took no part in actual operations. The U.S. Navy captain in charge of the Navy party escaped death in the Brazilian air crash by remaining behind a day.

* * *

POLARIS missile men are presently being trained at Cape Canaveral by Lockheed representatives. Next month the Navy will begin training these men at the Guided Missile Training Center, Dam Neck, Va., using Lockheed trained Navy instructors. Admiral Burke revealed in testimony before the House Armed Services Committee that we will have a 2,500-mile POLARIS missile in 1963. In a speech later, he stated that POLARIS missiles can be fired at the rate of one a minute. Navy's forty years experience in ejecting torpedoes from submerged tubes by compressed air helped develop the POLARIS ejection method quickly. The launchers, in effect, are torpedo tubes turned from the horizontal to the vertical. The missile is making 51 miles an hour as it emerges from the water.

* * *

Lockheed Missile and Space Division has technical supervision of work at the POLARIS Navy Weapons Annex at Naval Ammunition Depot, Charleston, S.C. This new activity will process and issue POLARIS missiles to ballistic missile subs, with Lockheed and Navy men working together. Commander Harry Cox is first officer in charge of the unit.

* * *

In answer to the question why the FY 1961 budget request for ASW *research and development* funds is down from 1959 and 1960, Navy officials replied:

"Year to year fluctuations within the program are not significant. These figures represent NOA (New Obligational Authority). Actually, it is likely there will be a spill over in '61 in the Research and Development category and we envisage a pretty level program at about $200 million a year. In case of a breakthrough, additional funds from the Department of Defense emergency R&D fund of $150 million could be shunted into ASW.—This is a matter of planning. We buy what is needed to equip."

* * *

The planned NIKE-ZEUS missile test range in the Johnston Island-OAHU area of the Pacific Missile Range will be used to test NIKE-ZEUS against POLARIS missiles. General Arthur Trudeau, Chief of Army Research and Development, stated POLARIS missiles would be easier targets than ICBM's. He did not predict flatly that the NIKE-ZEUS could handle either one.

* * *

The Anti-Submarine Defense Force Pacific under Vice Admiral J. S. Thach was established on the 1st of this month. Adm. Thach brings his experience in starting Task Force ALFA to his new command. Headquarters will be in Pearl Harbor. The Navy now has for the first time a Pacific and an Atlantic Anti-Submarine Defense Force.

* * *

After nearly 30 years of use, the MOMSEN LUNG, invented by Vice Admiral C. B. Momsen, USN (Ret), has been completely displaced by the "buoyant assisted" method of escape from a submarine. This involves use of life jacket and control of breathing in free ascent.

* * *

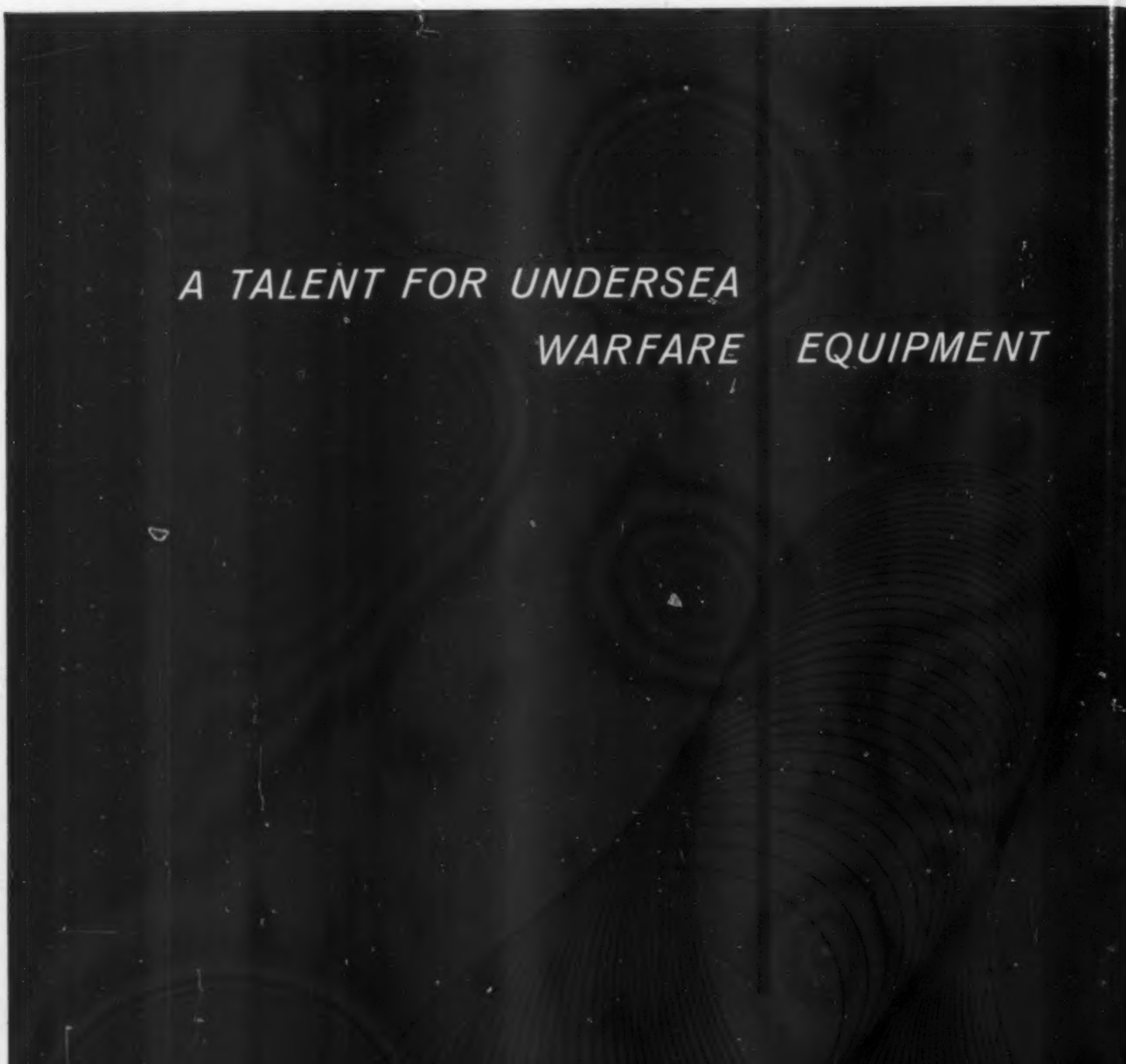
Mr. Vernon M. Bugg, of New Jersey still has to convince the Navy that he has a revolutionary "new method" of detecting submarines at long range. The Navy demands either a reasonable theoretical explanation of his method or a practical demonstration. Mr. Bugg decided to give a demonstration when he is ready. The Navy has not heard from Bugg on the date.

SALT WATER SHELL GAME

Find the sub. It is somewhere in the ocean basins that cover 70 per cent of the earth's surface. Listen for its motors. Find the hum that is lost in the din of marine life. Keep the sub at a safe distance. With one of its nuclear missiles, it can destroy any U. S. city. Don't be decoyed by a single prowler . . . an estimated 450 more subs need watching, too. So go the steps in one of history's toughest defense problems. So runs the routine aboard Navy ships and planes. Round-the-clock work reinforced by the efforts of American industry and ingenuity to provide the equipment needed to cut the Free World's biggest menace down to size.

AERONAUTICS | ASTRONAUTICS | ELECTRONICS | GENESYS CORP | RANGE SYSTEMS | RESEARCH

CHANCE VOUGHT
DALLAS, TEXAS


A TALENT FOR UNDERSEA
WARFARE EQUIPMENT

underwater sidelights

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

By E. E. Halmos Jr.

"Underwater engineering" is an old story to civil engineers and construction contractors—but their view of it probably requires some definition in relation to the much broader field to be covered by this publication.

To construction men, it means, quite literally, building something under water. They've been doing that almost since the first structure of any kind was built. In fact the first recorded tunnel (for pedestrians) was built by Greek religionists about 600 B.C., under a small river to connect two temples.

In fact, it has been the hard lessons that construction men have learned in their efforts to build things under water that have given rise to much of the knowledge of underwater conditions that exists today. For example, when the Brooklyn Bridge was built early in the 19th century, nobody knew anything about the effects of pressures on a man's body. Many workmen were killed in the crude caissons used to sink the bridge foundations nearly 150 ft below the East river: The bridge's designer, Col. Washington Roebling, himself was rendered a hopeless cripple by a case of the "bends" he contracted while supervising the work.

Diving bells, caissons—the basic structure of the submarine itself—came out of the efforts and the often tragic lessons learned this way. The use and regulation of air pressure, both to maintain a livable atmosphere and to control the surrounding water came out of it. Oddly—in reverse, these lessons apply just as well to the upper atmosphere, where the problem is not enough pressure, rather than too much.

But many of the materials and methods that have been developed will stand this nation in good stead, now that the vast areas under the oceans have become a matter of prime importance, both for defense and for future commerce. For example, the concreting of the underwater test stand for Polaris (see p. 47 of this issue) was done by a method (which is patented) especially developed for underwater work: The stone that will become part of the final concrete is placed first, and accurately, then a "slurry" (a thin mix) of water, cement and sand—which is heavier than the surrounding water—is pumped in, to cover the already-placed stone. The result is accurately-controlled concrete, in the right place at the right time.

Another material is a family of "flash set" cements—mostly containing a high percentage of alumina. Concrete made with this type of cement, for the most part, can't be used "in the dry," because it hardens so fast as to be unmanageable, and sets up so much heat in the process that it will crack. But it is ideal for use under water—and has been used for many years for underwater repairs of dam and bridge structures, for example.

You can add a couple of other techniques too: The knowledge of how to make a pretty sizable "hole in the water"—commonly used in bridge construction—where men can work in the dry. That's done by using sheetpiling to make a watertight box around the area to be worked on, pumping it dry, bracing it properly to withstand outside pressures.

And, where this isn't possible, or circumstances dictate, construction men first developed the "Texas Tower" idea, later taken up enthusiastically by oilmen. This is essentially a barge with legs—legs that can be lowered through the barge to the bottom, and on which the barge can then hoist itself to be clear of the water. These "towers" have been used for temporary, quickly-erected docks; for oil drilling, and even as derrick-bases, mounting extremely heavy lifting equipment to work on construction below.

The Navy, with its need for docking and repair facilities, has always been a leader in this kind of work. There's another reason too: The Navy usually hasn't much choice as to where it will build its facilities, must build them usually in already-established naval areas. Some of these are very poor from a construction standpoint—and so the Navy has developed many techniques for building underwater on bad foundations.

(You can't leave the Army's Corps of Engineers out of this, of course. In its historical job of preserving the nation's ports and harbors, it also has contributed much to the knowledge and the techniques of building under water.)

salty sayings

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"Engineers today are thinking in terms of five, ten, twenty years from now and looking forward to projects that are just a gleam in the eyes of those who fix requirements."

Dan R. Kimball
President, Aerojet-General Corporation

"An important aspect of all Navy League members this year will be to impress upon their Congressmen and Senators that we are against the single chief of staff concept which takes from the Congress much of its rightful control over the military as set forth in the Constitution."

Frank Gard Jameson
National President, Navy League of the United States

"Our Anti-Submarine Warfare program, which has been given priority at the highest levels, is designated to give our ASW forces the tools to meet and contain the Submarine threat. . . . We are buying latest developments in detection, classification and underwater communication equipment for subs, surface ships and aircraft. 1) For ships: data converters, variable depth sonar, drone control equipment. 2) For subs: communication buoys, data gather equipment, submarine IFF and secure communications. 3) For aircraft: sonobuoys, JULIE-JEZEBEL gear, and high powered dipping sonars for helicopters."

Admiral Arleigh A. Burke
Chief of Naval Operations

"We would like to discover construction materials which have both significant structural strength and internal damping capacities. This knowledge is now non-existent, and acquiring it is a preliminary requisite to design and construction of less noisy naval machinery components as well as resiliently mounting them."

Rear Admiral R. Bennett
Chief of Naval Research

"The general areas most intensively stressed in research and development are anti-submarine warfare, air defense, and space requirements. With a primary mission to keep the seas and thereby our own and friendly forces free, a large effort is directed toward the strongest of anti-submarine measures."

Vice Admiral J. T. Hayward, USN
Deputy CNO for Development

"We will continue to go to the most promising sources with our research and development requirements. To the extent that we are able to evaluate the comparative capabilities of companies in the R&D fields, we will avoid costly and wasteful effort by industry in preparing technical proposals."

Cecil P. Milne
Assistant Secretary of the Navy (Material)

"While science and technology have generated a phenomenal rate of progress, the new capabilities available to us in the space age will be of little value unless our military thinking progresses at the same exciting rate."

Rear Admiral John E. Clark, USN
Commander, Task Force ALFA

"Certainly sea power will play a vital role in any limited war. Upon reflection,—to fight such a war without command of the sea on the part of the U.S. and its Allies in the free world is unthinkable. And should the deterrent fail and general war ensue, the seas will give us the time and space factors we need for early warning and for defense in depth; as well as vast maneuver areas for dispersal and concealment of our striking forces."

Admiral James S. Russell, USN
Vice Chief of Naval Operations

"The Navy has always insisted on a degree of technical thoroughness that has been unexcelled in this country. This probably derived from "Across the board background" of Navy knowledge of sea, land, and air operations and environments as an integral part of the Navy's operations."

Rear Admiral K. S. Masterson, USN
Assistant Chief of Naval Operations
(Development)/Director of Guided Missiles

underwater engineering

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underwater engineering

pilot issue march, 1960

how big is the underwater engineering market?

UE Staff Report

Before Fiscal Year 1960 is over, the Navy will spend between \$2.13 billion and \$6.75 billion on anti-submarine warfare equipment and activities. About \$500 million of this money will go for procurement of electronic gear used only for ASW work. The Navy will spend almost \$160 million to modernize electronic gear on older ships to make them suitable for submarine-oriented warfare.

The majority of this money will be spent by the Bureau of Ships. A part will be spent by the Bureau of Naval Weapons, carrying out a function of the former Bureau of Ordnance.

Most of this money will be spent in four major areas. The exact amounts allocated to each area is classified, but some pertinent figures which help in estimations will be presented later in this report. The areas are these:

1) Building new ships.
2) Modernizing and/or converting.
3) RDT&E and procurement of all electronic gear associated with ship navigation.
4) RDT&E and procurement of electronic gear assigned to ships undergoing BuShips conversion.

The Bureau of Naval Weapons' interest in ASW falls into these general categories:

1) Submarine-hunting aircraft.
2) Most airborne detection equipment.
3) Underwater explosives.
4) Some underwater explosive-carrying vehicles.

This is a large field that the Bureau of Naval Weapons is covering, but money-wise it is small in comparison to the billions being spent in BuShips' ASW shipbuilding program.

The Navy spends between 18 per cent and 60 per cent of its budget on anti-submarine warfare, depending on how much of an aircraft or a destroyer is charged to ASW. Navy fiscal officers are able to prove figures at both of these extremes. That leaves a lot of leeway for guessing, but a Navy spokesman says this is realistic: "The Navy is now using about 4-5 per cent of its total budget for research, development, and procurement of electronic detection gear alone." The Navy's FY 1960 budget is \$11,325,595,000, including \$99 million in transferred funds.

The Navy is spending over \$150 million per year on underwater explosives and the means of getting these explosives to the vicinity of an enemy submarine. Most of this work is being done by private firms. However, some of it goes on in Navy arsenals. For example, the Naval Weapons Plant, Washington, D.C. produces Mark 101 aerial depth bombs. At mid-fiscal year, the plant received a new \$6 million contract to produce another 700 bombs.

Two glamor projects are in the works:

1) ASROC, which is a surface-launched, long-range rocket.
2) SUBROC, a submarine-launched version of ASROC.

The Bureau of Naval Weapons is the responsible agency for most of this work. The contracts generally are small, or are spread out over several years. The biggest single ASW field under Bureau of Naval Weapons control is aircraft.

The Navy is spending about \$1.8 billion per year on aircraft. The majority of this money is going for helicopters and planes for ASW work.

The biggest single field in ASW — and the most lucrative for contractors — is in electronics. This covers communication, detection, and identification or classification. In the last year for which figures are available, 1958, the Navy spent \$200 million just on ASW Sonar, Radar, magnetic systems and related equipment for ASW. ASW

equipment procured just for the shipbuilding and conversion program in 1959 cost $135 million. A $200 million major program is being conducted in FY 1960. Here are the major areas in the ASW electronics field:

1) Magnetic Anomaly Detection (MAD).
2) Shipboard Radar.
3) Sonar.

Sonar is the most heavily funded ASW electronic device. Shipboard units cost between $25,000 and $50,000. About $10 million is being spent this year on small, expendable Sonobuoys, costing $175 each.

This fiscal year, the Navy will spend $1,770 million on shipbuilding and conversion programs, very slightly more than last fiscal year, and up appreciably from the $1,515 million spent in FY 1958. The following statement in the President's budget request for FY 1960 underscores the importance of these figures to ASW:

"The fleet rehabilitation and modernization program described earlier is aimed almost entirely at improving the condition and strengthening the capabilities of anti-submarine warfare vessels. These modernized ships, which will begin to rejoin the fleet by the end of 1960, will have significantly better Sonars, and will carry ASW helicopters and new ASW weapons. . . . During 1960, two additional ASW task forces will be operational."

Out of the total shipbuilding and conversion program, almost $200 million is for conversion of 13 ships. About $108 million is for conversion of a ship to a guided missile cruiser. About $85 million is being spent on conversion of 12 other ships, mostly to ASW use. This includes conversion of eight destroyers for complete ASW use. The money spent here is nearly all on electronics gear. In addition to conversion programs, $49 million is being spent to build a nuclear-attack submarine.

The Navy also conducts basic research in oceanography as part of its anti-submarine program. It expects to spend $65 million just on buildings and laboratories for a program called "Ten Years of Oceanography" (project Tenoc).

These Navy and private laboratories comprise the advisory Undersea Warfare Council:

U.S. Navy Electronics Laboratory, San Diego; U.S. Navy Underwater Sound Laboratory, New London, Conn.; David Taylor Model Basin, Carderock, Md.; U.S. Naval Ordnance Test Station, China Lake, Calif.; U.S. Navy Underwater Ordnance Station, Newport, R.I.; U.S. Naval Ordnance Laboratory, White Oak, Md.; Applied Physics Laboratory, Univ. of Washington, Seattle; Ordnance Research Laboratory, Pennsylvania State Univ., Philadelphia; U.S. Navy Air Development Center, Johnsville, Pa.; U.S. Naval Research Laboratory, Washington, D.C.; Woods Hole Oceanographic Institution, Woods Hole, Mass.; Scripps Institution of Oceanography, Univ. of Calif., Berkeley; Budsen Laboratory, Columbia Univ., New York, N.Y.

The United States is funding, for the first two years, the NATO-SACLANT anti-submarine warfare research center commissioned in May, 1959, at La Spezia, Italy. The money is from mutual defense weapons funds. Scientific support comes from these member countries: Canada, France, Germany, Italy, Netherlands, Denmark, Norway, United Kingdom, United States.

The Navy plans to cooperate with other organizations notably the National Science Foundation, in organizing for mass oceanographic studies. A sympathetic Congress is expected to vote additional funds for this purpose. The U.S. entered FY 1960 with only one oceanographic vessel; the Senate Preparedness Subcommittee was surprised to learn that Russia has about 15 such special ships.

Much of the Navy's oceanography funds are spent through its own David Taylor Model Basin, near Washington, D.C. However, the Basin, a BuShips function, does farm out some work to other laboratories; including New York University, Scripps Institute of Oceanography, and Woods Hole Oceanographic Institution.

The Bureau of Ships contributes to oceanographic research in three ways:

1) Builds equipment useful in delineating the ocean.
2) Assists in development of instruments which define the limiting factors controlling design of military equipment and weapons systems.
3) Provides direct research support of certain priority items, such as those in ASW.

BuShips not only gathers and distributes oceanographic data, but it also buys data for its own needs. Example: A number of research organizations and other government agencies were consulted by BuShips for advice and assistance in designing the oceanographic research ship in this year's budget.

The Navy is contributing to the National Academy of Sciences - National Research Council's Moho project through a small ONR grant to study the conversion of an off-shore drilling ship to deep water drilling. Surveying and test hole drilling will cost about $2.5 million, to be contributed by individuals and private industry. Actual drilling of the hole through the Moho, and analysis of results, will cost another $12.5 million, expected to come from both private and government sources.

The NAS-NRC Committee on Oceanography is gaining wide support —including that of Navy and Congress—for its proposed program to double the U.S. oceanographic research effort in the next 10 years. The Committee wants to see a 10-year expenditure of $651,410,000 over and above the present effort.

Here is how the Committee thinks the program should be financed:

The Navy and the National Science Foundation should each finance about 50 per cent of the new basic research activity except ship construction. The Navy should finance 50 per cent of the new research ship construction, with the Maritime Administration and National Science Foundation sharing the remainder. The Navy Hydrographic Office should finance 50 per cent of the deep ocean surveys, the rest to be financed by Coast and Geodetic Survey. The Navy should pay for all military R&D. The Bureau of Commercial Fisheries should pay for most of the ocean resources program. The Atomic Energy Commission should finance the biggest part of research dealing with radioactive contamination of the oceans. The National Science Foundation and the U.S. Office of Education should jointly sponsor the program of increasing scientific manpower in marine sciences. Other agencies which should pay for all or part of small segments include the State Department, Bureau of Mines, International Cooperation Administration, and the U.S. Public Health Service.

The Committee calls for construction of 70 ships of 500 to 2,200 tons displacement between 1960 and 1970, and modernization of, or retirement of, the present fleet of 45 small ships. This will cost $213 million.

The activity conducted by each ship will call for about 60 shore-based technicians, construction of $1.5 million in shore facilities, and annual operating expenses of $1.2 million. Survey ships, too, will need shore facilities. The recommended initial expenditure is $750,000, and an equal amount each year to cover new ships as they are put into service. The Navy and the Coast and Geodetic Survey should cover these costs.

Manned submersibles, mid-ocean platforms, ice-breaking submarines, etc., will cost $100,400,000 over 10 years.

Research on radioactive contamination will cost about $44,130,000.

Studies of marine biological resources will run $78,540,000 for the 10-year period.

Here is a financial breakdown of the total recommended increase:

Navy	$278,240,000
Coast and Geodetic	78,040,000
Bu. Commercial Fisheries	123,160,000
Maritime Adm.	10,900,000
National Science Foundation	121,040,000
Office of Education	5,000,000
Atomic Energy Comm.	32,430,000
Bureau of Mines	2,600,000
TOTAL	$651,410,000

Here is a breakdown of Navy budget items pertinent to ASW for recent years. The figures are actual expenditures for FY 1958, and the Navy's own estimate for FY 1959.

Aircraft and Related Procurement

Ground Electronic and Detection Equipment—procurement of communication systems, navigation aids, electronic instrumentation for aircraft test ranges, and technical material for detection of submarines by aircraft . . .
1958 $29,443,000
1959 $64,000,000

Shipbuilding and Conversion

Electronics Major Procurement—procurement of electronic equipment for fleets and fleet support activities, and all gear required in connection with ship operations . . .
1958 $84,035,000
1959 $135,923,000

Procurement of Ordnance and Ammunition

1) **Ammunition**—procurement of ammunition, mines, depth charges and torpedoes, acquisition and construction of production facilities . . .
1958 $111,117,000
1959 $116,013,000

2) **Ordnance Equipment**—procurement of fire control equipment, guns and mounts, nets and degaussing, aviation ordnance, acquisition and construction of facilities . . .
1958 $7,436,000
1959 $12,322,000

Research and Development

1) **Ships and Small Craft and Related Equipment**—research and development of ships and small craft and their components, such as hulls, engines and propulsion machinery, guns, radar, sonar, fire control systems and other electronics equipment of shipboard use, catapults and arresting gear, shipboard mine countermeasures equipment, and other installed equipment . . .
1958 $83,508,000
1959 $110,295,000

2) **Ammunition and Related Equipment**—research and development of mines, depth charges, rockets, bombs and clusters, torpedoes and other types ammunition, and related components . . .
1958 $40,870,000
1959 $56,408,000

3) **Other Equipment**—research and development of equipment not separately provided for under other budget programs, including certain navigation, detection, and warning equipment, harbor defense equipment, shore-based anti-submarine and mine counter-measures systems, training devices, radiological and aerological equipment, and personal *(sic)* equipment . . .
1958 $30,752,000
1959 $47,593,000

Obligations incurred in all R&D programs are attributed to various Naval organizations as follows:

(in millions)

	1958	1959
Office of Naval Research	$ 80.2	$ 82.0
BuAeronautics	167.4	182.1
BuShips	88.3	118.8
BuOrdnance	235.7	354.3
BuMedicine & Surgery	4.5	5.0
BuYards & Dock	3.4	3.5
BuSupplies & Accounts	0.9	2.3
BuPersonnel	0.7	0.8
Marine Corps	4.8	6.9

Service-Wide Operations

Hydrographic Office—navigational and special military charts, publications and studies on a world-wide basis . . .
1958 $11,378,000
1959 $12,265,000

The Navy shipbuilding and conversion program planned for FY 1960 is interesting to persons engaged in ASW work. Here is a look at a few of the details that pertain to ASW:

One Liberty Ship is being converted to a technical research ship (AG) by the New York Naval Shipyard. It will be a mobile base for research in communications and electromagnetic radiations.

The Charleston, S.C., Naval Shipyard is converting one postwar steam-driven LST into an advanced aviation base ship (AVB) to provide facilities for ASW aircraft operating from forward bases where no facilities exist. It replaces the only ship of its type, the USS *Alameda County*, due for retirement.

Three new guided missile destroyers are being built, primarily as ASW ships, although in addition to ASW gear, they would mount twin Tartar short-range, surface-to-air guided missile batteries.

A new escort vessel (DE) is being built, incorporating a new design that would offer improved seaworthiness and anti-submarine capabilities. It will be the first new ship to carry the new integral bow-mounted long range Sonar and Drone ASW helicopter (DASH).

A new oceanographic research ship (AGOR) is under construction.

A new submarine chaser (PCH) with hydrofoils will be built to conduct slow-speed ASW searches.

Navy Budget for the past three years.

	FY 1957 actual	FY 1958 actual	FY 1959 estimated
	(In Thousands of Dollars)		
Military Personnel Cost	3,080,010	3,082,112	3,146,009
Operations and Maint.	2,475,453	2,493,928	2,563,119
Major Procurement & Prodn.	3,754,748	4,232,702	4,400,676
Aircraft	*1,995,840*	*2,207,386*	*1,959,820*
Missiles	*264,308*	*345,151*	*481,327*
Ships & harbor craft	*863,658*	*1,138,157*	*1,396,611*
Combat vehicles	*45,131*	*33,073*	*18,000*
Support vehicles	*28,270*	*13,999*	*22,201*
Artillery	*59*	*16,134*	*1,000*
Weapons	*11,652*	*10,657*	*5,439*
Ammunition	*277,5C2*	*160,667*	*200,501*
Electronics & communications	*119,103*	*142,759*	*189,152*
Prodn. equip. & facilit.	*67,687*	*79,589*	*50,010*
Other maj. proc. & prodn.	*81,538*	*85,130*	*76,615*
Military Construction	369,888	405,780	401,460
Reserve Components	225,926	219,710	226,380
Research and Development	522,500	569,072	717,181
DOD-wide Activities	25,293	27,339	32,625
Working Capital Funds	−102,962	−176,399	−15,450
Undistributed	47,458	51,941	—
TOTAL	10,398,315	10,906,185	11,472,000


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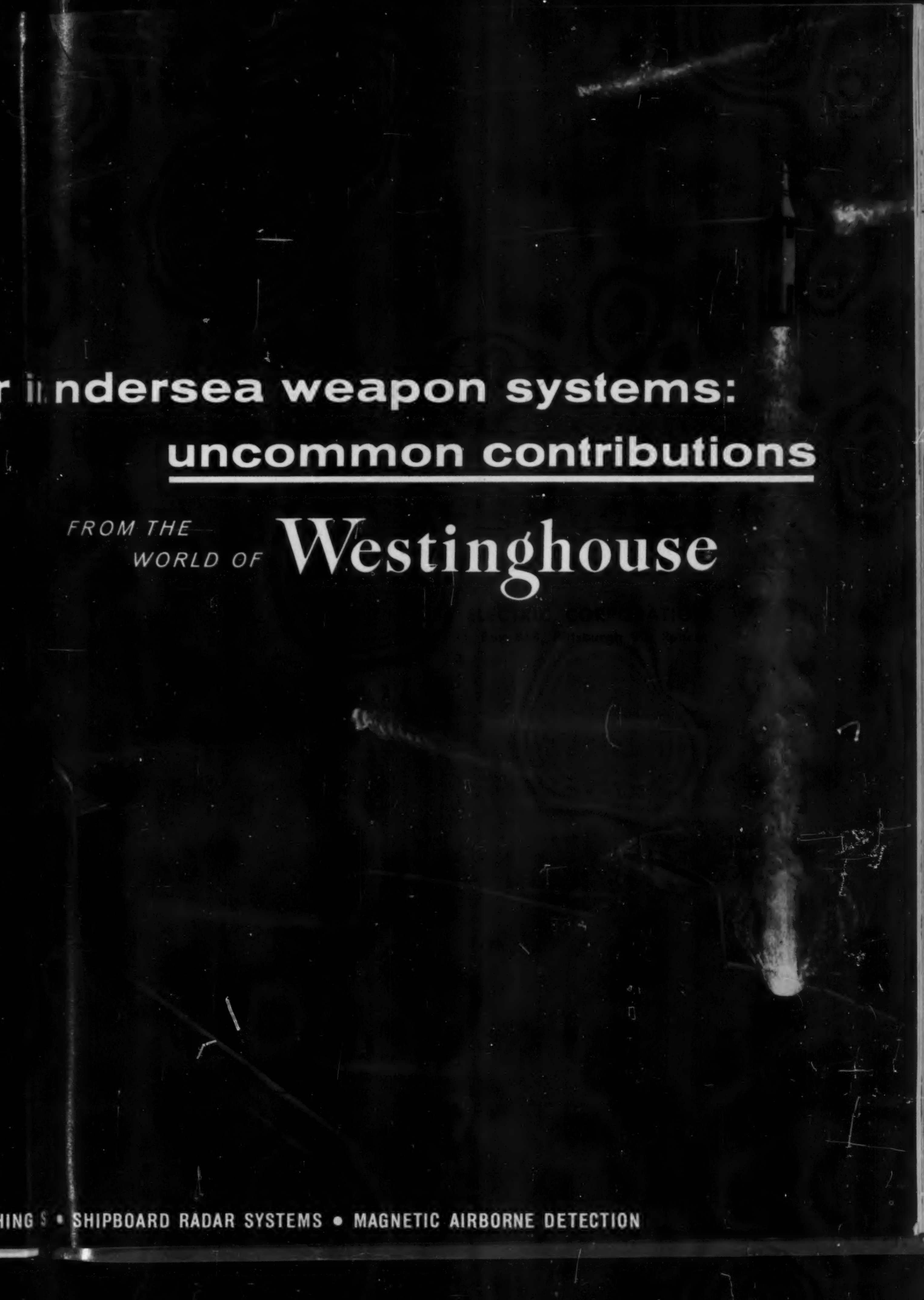
TORPEDOES • SONAR SYSTEMS • MISSILE LOADING & LAUNCHING S


r undersea weapon systems:
uncommon contributions
FROM THE WORLD OF Westinghouse
HINGS • SHIPBOARD RADAR SYSTEMS • MAGNETIC AIRBORNE DETECTION

birth of the underwater rocket

By Erik Bergaust

The birth of the submarine-launched rocket is an interesting one, and one that is generally unknown. Certainly, it is not known that Dr. Wernher von Braun, boss of the big booster work at the National Aeronautics and Space Administration, is the man who initiated the work that led to *Polaris*, *Asroc*, *Subroc* and other rocket-powered underwater missiles. It started back in 1943. . . .

With the sea chuckling around her elevated periscope U-boat Z-145 slowly moved toward the busy harbor of Casablanca. The morning haze was moving out to sea, and submarine commander Fritz Steinhoff of the German Navy could get glimpses of the African coast. His diesel-powered ship moved steadily forward, alert and ready to smash her torpedoes into any allied ship going into or coming out of the harbor. But this was a quiet Sunday morning—despite the fact that the African battles between Montgomery and Rommel were at their peak of intensity. In fact, Commander Steinhoff could see smoke and ripples of fire burst in shining flashes on the horizon to the south. But the sea was calm. No ships were in sight.

He called a meeting of his officers to discuss the next move: going into the harbor itself. To the best of their knowledge Casablanca did not have a submarine net. Yet they decided the safest approach would be to wait for the moment when a ship would be entering and then follow closely behind and settle on the harbor bottom.

The crew was briefed on the forthcoming maneuver. At half-hour intervals Steinhoff took the sub up to periscope depth and carefully scanned the coast. In the early afternoon he was rewarded for his patience. Moving up from the south was a big four-master freighter, obviously headed for Casablanca. Steinhoff could see no escorting vessels, no airplanes overhead.

He ordered full speed ahead and began plotting the intercept course that would bring him to a convenient rendezvous with the freighter as close to the harbor as possible. At this point he was perhaps 10 miles from the coast. With a little luck he would be able to intercept the freighter at a point just about two miles from the harbor entrance.

Half an hour later Steinhoff again brought his sub up to periscope depth and quickly poked up his periscope to get his bearing on the freighter. The ugly, camouflage-painted freighter was coming right at him, less than half a mile away.

"Down periscope," Steinhoff ordered again. "Take her down to 50 feet. Cut engines."

The atmosphere aboard the Z-145 was tense now. Although no orders had been given to exercise silence, the men knew what to do in this kind of situation.

Moving ahead at only 5 knots Z-145 approached the coast undetected. It was Steinhoff's plan to sneak into the harbor, because intelligence reports said an excessive amount of allied shipping was concentrated in Casablanca, unloading tanks, trucks and other equipment for what appeared to be a major campaign.

At close range, scanning the coastline and the harbor entrance carefully, Commander Steinhoff could count the funnels and masts of several dozen ships. The intelligence reports were correct. Something big was going on. "Take her down to 100 feet. Stop the engines."

of situation. Only the hum from sonar-type equipment could be heard. The signals were coming in at a steady pace, increasing in intensity.

"Sir," said the sonar man, "she's right over us."

Steinhoff gave the orders to move ahead. With the utmost precision he maneuvered the sleek Z-145 right up under the propellers of the freighter, navigating only by sonar. The rest of the job was easy. With his detail maps of Casablanca harbor, calibrating his speed and depth, Steinhoff slid into the harbor and settled silently on the bottom.

The German U-boat threat had been the most troublesome and certainly the most unpredictable element of the war so far. By the end of 1941 Admiral Donitz's U-boat fleet counted some 250 units. Every month fifteen new submarines came off the ways at German ship yards. They were operating all over the Northern hemisphere. They ravaged American waters almost uncontrolled. According to Sir Winston Churchill the German U-boat menace almost brought the allies to the disaster of an indefinite prolongation of the war. "Had we been forced to suspend, or even seriously to restrict for a time, the movement of shipping in the Atlantic, all our joint plans would have been arrested," Churchill wrote.

Commander Steinhoff's large submarine (740 tons) had been ordered to take part in the North Atlantic raids during 1942. On December 12 of that year Hitler and his admirals initiated what were to become the most consistent and concentrated attacks on the Atlantic convoys. According to official reports the first six of the large German subs left their Biscay ports between December 18 and 30 and by the end of January had sunk 200,000 tons of allied shipping, or a total of 31 ships. As other U-boats joined the pack the Germans struck and killed from the Arctic to the Mediterranean, from Venezuelaen waters and the Gulf of Mexico to the British Channel. The menace was overwhelming. . . .

After careful consideration Commander Steinhoff decided to make his first move at dusk. The men were tense. In the past twelve hours they had been maneuvering under water. The very thought of being trapped at the bottom of an allied harbor did not do much to boost their morale. When Steinhoff called for action, every crew member was relieved. The waiting was over.

At periscope depth Steinhoff first saw the flaming Western sky which had turned purple. Then, as he swirled the periscope around, he no-

ticed an almost fantastic activity. From dozens and dozens of ships supplies and equipment were being unloaded and stacked on shore. Hundreds and hundreds of tanks, trucks, and guns and thousands of barrels of gasoline and oil were placed in mountainous heaps in the off-loading areas. Cranes on shore and booms on the ships were swinging back and forth. To Steinhoff this activity clearly indicated that a major offensive was in the offing. But what could he do about it? He immediately realized that he was a sitting duck in the midst of this fabulous nest of allied activity. He probably could fire as many as five or six torpedoes and sink two or three empty cargo ships. But this would mean suicide. They would descend upon him as hawks before he would have a chance to turn around and get out of the harbor. Certainly, he could not use his torpedoes against any targets on shore—in all, the situation was a disappointing one.

"Down periscope," he said again.

He gave orders to go back down to the bottom. Waiting for the African night to spread its darkness over the harbor area, Steinhoff and his officers quietly discussed with dismay the sad situation. And at this moment Steinhoff conceived an idea that might have changed the outcome of the war —had it been realized sooner.

"What we need," he told his officers, "is some sort of torpedo that can pop out of the water and hit targets on shore—some sort of *rocket*, perhaps."

In the still of the night Steinhoff took his Z-145 out of the harbor. From their sonar readings they had established that there was no submarine net. Completely undisturbed and undetected the big submarine finally surfaced to give the crew a break and to recharge the batteries. In the tropical night Steinhoff remained on his bridge for a long while. Headed north, back to Germany for a routine overhaul, he began to formulate some hard-boiled ideas for a submarine rocket.

Upon his arrival in Kiel, the great German submarine base, Steinhoff hurried ashore and soon found himself on a train to nearby Peenemunde Rocket Center. At this time only a few people in Germany knew about the rocket establishment, but Steinhoff was aware of what was going on—to some extent. His brother, Dr. Ernst Steinhoff, was Dr. Wernher von Braun's No. 2 man and in charge of all missile guidance projects. It seemed an obvious thing for the submarine commander to get in touch with his brother and discuss the possibility of developing a new navy weapon—one so fantastic that *der Fuhrer's* great submarine fleet possibly could bring an early end to the war.

His brother was meeting him at the station. They had not seen each other for a long time, and the reunion was indeed a happy one to both of them. Dr. Steinhoff had arranged for a pass for his brother, and after their arrival at Peenemunde, the eager submarine commander immediately began to outline his ideas. Could a rocket be launched from underwater and hit targets on shore? Could rockets be fired through the torpedo tubes? Or would the submarine blow up? In fact, could rockets "fly" underwater?

Dr. Ernst Steinhoff hesitated. For a moment he thought of the control problems, the guidance and the electrical circuitry required for such a rocket. Then he said: "I don't know. I imagine that guiding a rocket underwater would have to be done in a similar fashion to that used for torpedoes. But I don't know if a rocket *will work* under water. But we shall find out. I'll introduce you to my boss —he can tell us."

The boss was Wernher von Braun. And the boss could tell. In fact, his first reaction was summed up in these words: "If a rocket can work in space it also can work in water. Interesting —I never thought of this. Let's try and figure it out."

The next day Commander Fritz Steinhoff of the German Navy found himself involved in a top secret planning meeting of the most important Army rocket scientists at Peenemunde. Von Braun, Steinhoff and their men drew sketches and talked about back pressure, squib igniters, sealed nozzles, burning time, cutoff velocity and many things he did not understand. But within a *matter of hours* von Braun had a rough outline for an approach he considered sound. He suggested that a steel launching structure with racks for six rockets be mounted on the deck of a submarine. The rockets would be resting in a 45 degree angle. They were to be 22 cm *Borsig* solid-propellant artillery rockets. The nozzles were to be sealed with candle wax, through which electrical wire would be leading to a squib igniter. The wires would lead through the conning tower into the submarine's main control room. To Commander Fritz Steinhoff a dream was beginning to come true. He was thinking of glorious victories. "We must not waste one moment," he told von Braun.

At this time the V-2 program was not going at top speed, by no means, and General Walter Dornberger, Peenemunde's commanding officer, told von Braun he had no objection to von Braun "playing around" a little with this submarine rocket—provided it did not take up too much time. Perhaps this could be done in their *spare time*, he suggested.

The young U-boat skipper did not like that approach at all, but von Braun smiled and said: "Don't worry —the old man is just a little concerned about playing around with a Navy project without clearance from the Admiralty. However, if we do this on a voluntary basis—sort of like a hobby—nobody will be sticking their necks out. Why don't you arrange for two or three weeks leave? Furthermore, you've got to get us a submarine!"

Fritz Steinhoff rushed back to Kiel and discussed the matter intimately with his immediate superior, an old admiral due for retirement and one of those eager enthusiasts who did not buy Berlin's red-tape approach at all. He told Steinhoff to go ahead, and in a matter of days Commander Steinhoff was headed east into the Baltic with an old submarine, useless for war work, but still running.

By that time von Braun's technicians had welded together the steel rack for the *Borsig* rockets, and before long the contraption was mounted on the deck of the submarine. A peculiar part of the program occurred when a purchase order for 500 wax candles was issued. "What the hell do you need 500 candles for?" the procurement officer asked. The engineer who had been assigned to direct the project, said: "We're building a *new kind* of rocket. Supersecret!"

The wax was melted in a pot. The bulky infantry rockets were turned upside-down, the electric wire mounted in the nozzle which then was sealed with the liquid wax. One by one the six rockets were placed in position, pointing skyward at 45 degree angles, in the steel structure on the deck. About twenty scientists and technicians, plus the crew from Steinhoff's submarine were pitching in on what appeared to be a "rather interesting" experiment to von Braun. In the early afternoon that day the sub went down to 100 feet to get ready for the launching. Von Braun had instructed his men to install cameras on shore to take movies of the rockets—*if* they came out of the water.

Telephone contact was established between the sub and the men on the shore. A regular countdown proceeded, and at the all-clear signal from von Braun Commander Steinhoff pushed the button. After about two seconds of waiting the men on the shore saw the first rocket pop out of

the water in a big splash and streak toward the heavens with a wooshing roar—in a perfect 45 degree path! Then the second rocket followed the first. And the third, and the fourth, and the fifth, and the sixth!

Upon the request of Commander Steinhoff von Braun had his project director prepare a detailed technical report on the underwater rockets. Among others, it was found that the burning of propellant under water was not significant because of the great back pressure caused by the density of water. When the rocket popped out of the sea, it easily had 90 per cent of its propellant left. Consequently, the range of the missile was practically the same as if it had been launched from a shore installation. "With this device I can blast Casablanca harbor—or any other shore target — from positions miles out at sea," Commander Steinhoff exclaimed.

A detailed report was sent to the German Admiralty, but bitter disappointment was in store for the underwater rocket inventors. The German Navy insisted on developing its *own* launching gear for underwater missiles. Service jealousies—not unlike those in the U.S.—hampered the entire experiment and a program was not even started by the end of the war.

Disgusted with the treatment his project had been given, Commander Steinhoff was ordered back into the Atlantic. He took his submarine into Boston harbor on V-E Day to surrender to the U.S. Navy. Before the Americans came aboard to take him and his crew as prisoners of war, he drew his pistol and shot himself. . . .

It is almost ironical that the U-boat captain's brother, Dr. Ernst Steinhoff, came to the United States also—but as a member of the von Braun missile team. He went to work for the United States Air Force and for many years has served as a guidance expert for Air Force missile projects at Edwards Air Force Base in California. Not so long ago, Dr. Steinhoff joined private industry.

When the technical reports and the movies of the underwater *Borsig* experiments were brought to the attention of the U.S. Navy, back in 1945/46, a program was being carried out by a small submarine detachment experimenting with the launching of a V-1 type buzz-bomb missile *(Loon)* from the deck of a submarine in *surfaced* position. These experiments led to development of the *Regulus* I and II missiles, also to be fired from surfaced submarines. But when our Navy learned that the Russians had captured the German underwater rocket gear and probably had submarines capable of launching rockets *(Golem)* from *underwater* positions, top Navy brass began to take a new look at the situation. Several meetings were held between von Braun and his scientists at Redstone and Navy missile men.

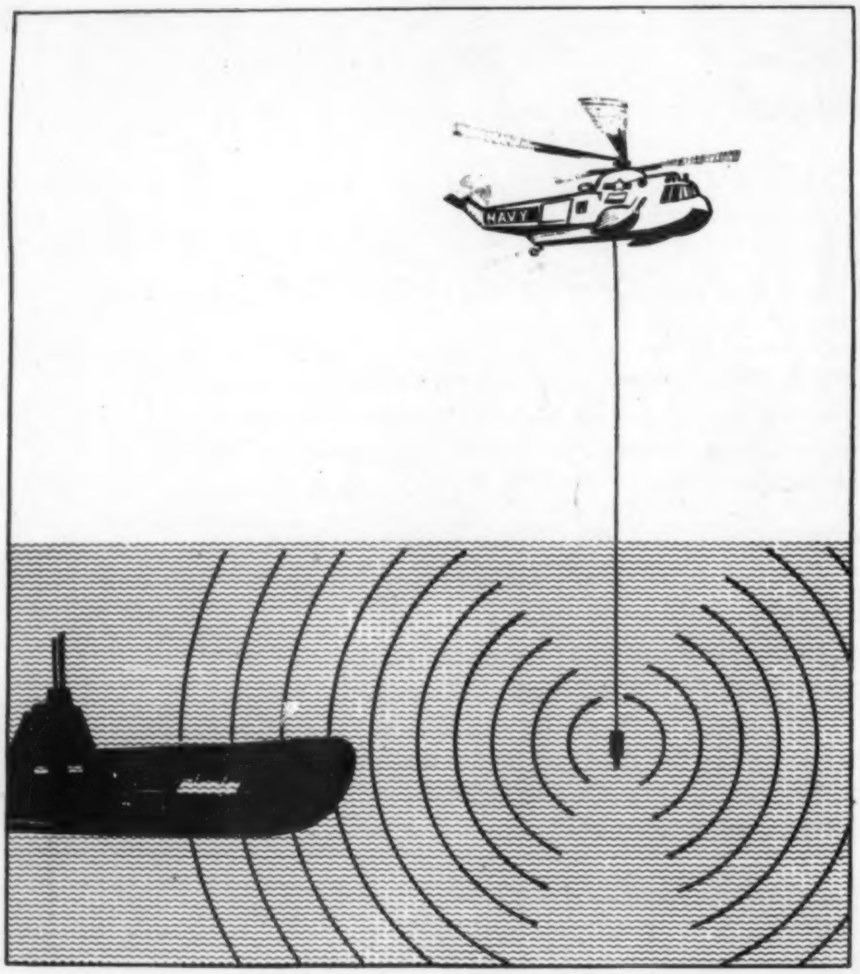
It sounded almost unbelievable to the Navy men when von Braun told them that there was no reason in the world why submarines could not launch intermediate range ballistic missiles. The *Jupiter*, von Braun said, would be a perfect missile for the Navy.

In the following months the Navy Department became busy. Could the Navy hook up with the Army on a joint IRBM program? The Navy sent a top delegation to Redstone to find out.

A potent Army/Navy team was born and planning for missile-carrying nuclear submarines progressed rapidly. At this time Major General John B. Medaris had moved in in full force and with his vigor the program picked up speed.

As the joint *Jupiter* program advanced it became clear to the sailors that the new weapons system was to become much more complex than originally planned. This fact stemmed from the use of liquid oxygen and kerosene aboard a ship. Very intricate liquid oxygen equipment was planned for the vessels, and an insurmountable array of safety procedures would be required. The possibility of propellant explosions, toxic fumes and similar hazards involved in liquid-propellant missilry became evident to the Navy, and when the solid-propellant manufacturers convinced the Navy men that they had advanced so far in solids that IRBMs could be built, the Navy reviewed the program and finally decided to back out. A solid-propellant *Jupiter* seemed much more attractive, there would be no need for the dangerous fueling equipment, the solid missile could be handled just about the same way as a shell. So the Navy backed out and set up its own Special Projects group under the able direction of Rear Admiral W. F. Raborn. The Navy missile was often referred to as *Jupiter B* in those days, and the first thing Admiral Raborn did was to give the missile a new name. It was christened *Polaris*. Thus, in January, 1957, the Navy entered the ballistic missile field on an independent basis.

The 3-foot long *Borsig*—fifteen years later—was turned into the 26½ foot *Polaris*, the pride of the U.S. Navy. On his 46th birthday, March 23, 1958, von Braun was told that the Navy had successfully fired a dummy *Polaris* from an underwater test stand. . . .



transducers: key to sonar

By GEORGE RAND*
and
JOHN DEVINE†

Acoustic compressional waves in the sonic and ultrasonic ranges represent the most effective means of determining the range, bearing and depth of submerged submarines.

Because of this, electronic engineers are concentrating in many defense projects on the problem of developing improved sonar systems. Sonar, a word coined from *SOund, Navigation And Ranging*, generally applies to the various types of underwater sound devices for the detection of submerged objects. The devices are also useful in oceanographic work.

The key element of a sonar system is that instrument which translates the acoustic pressure fluctuations into electrical signals: the electroacoustic transducer. This unit affects both the transmitted acoustic energy level as well as the electrical signals received by the sonar. The transducer, too, is a controlling factor in the system's directional characteristics and its receiving signal-to-noise ratio.

In the parlance of the sonar engineer, the term, *transducer*, refers to a reversible device useful for both reception and transmission. A unit designed specifically for reception is known as a *hydrophone*, while its counterpart for transmission is a *projector*.

Sonars Are of Two Types

Sonars vary in complexity and scope. Their operational principles may be classified in two fundamental types. These are the *passive*, or listening, sonar, and the active, or echo-ranging, sonar.

The former is used to search for underwater noise-producing objects and can give target bearing at great ranges while remaining silent in itself. Active sonar is similar in operation to a radar system. Pulses of sound energy are transmitted into the water by the sonar transducer, and upon striking a submerged object, part of the sound energy is reflected back to the transducer.

In a passive sonar system the underwater sound is detected by hydrophones which are acoustically sensitive. When compressional sound pressures reach it, the hydrophone generates small voltages which are amplified and used to indicate the presence of the underwater sound source to the operator.

Active sonar makes use of an echo which indicates the presence of a submerged object. The time interval between the transmission and reception of energy serves as a measure of the range. Echo-ranging sonars have the advantage over conventional listening sonars of providing range information as well as bearing data. They have,

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however, the disadvantage of much shorter range.

Some Typical Transducers

A sonar transducer consists of several active elements. The latter may be either magnetostrictive, piezoelectric, or electrostrictive types. At the lower frequencies, some use is made of electro-dynamic transducers similar in construction to that of loudspeakers. The active elements are housed in metal or plastic with a rubber cover, or boot, isolating the elements from the water. Passive electrical matching elements complete the device.

Transducers may be classified also in respect to their radiating surfaces. These are plane-faced piston, multi-element cylindrical, and straight-line; known, respectively, as searchlight, scanning, and line transducers (or hydrophones).

A depth-sounding, circular searchlight sonar transducer, such as shown in the sketch at the botton of this page, weighs about 100 pounds. It incorporates a crystal array having an active diameter of 9 inches. The complete assembly has an over-all housing diameter of 16 inches and a height of about 10 inches. The steel housing contains two watertight compartments, the crystal array being mounted in one chamber which is covered by an acoustically transparent rubber boot.

The crystal plates, each 2½ inches long, 1¼ inches wide, and ¼-inch thick, are isolated by a rubber cork pressure-release material. The array is mounted on a metallic plate, referred to as the backing plate, in order to achieve a transducer resonant frequency lower than that obtainable with the basic crystals alone. An inductor tunes out the capacitive reactance of the crystals and presents a pure resistive load to the transmitter at the operating frequency.

Scanning Sonar Uses Staves

A scanning transducer consists of a cylindrical housing on which are mounted 24, 48, or more identical staves, each containing a number of active elements. The stave compartment is oil filled or separated by an oil layer from the rubber boot that is stretched around the housing. The central compartment of the transducer contains impedance-matching elements, usually one for each stave, and necessary cable entry and sealing holes. A bottom cover seals the central compartment from the sea water.

A typical crystal transducer of this type is shown in the illustration at the bottom of page ... It consists of 48 staves, has a diameter of 19 inches, an


U.S. NAVY EXPLORES THE

over-all height of 26½ inches, and weighs approximately 600 pounds.

The sketch at the bottom of page .. shows a line-type hydrophone. This consists of three 1½-inch diameter 1½-inch high barium titanate ceramic cylinders, corprene separators, and a rubber coating to insulate the cylinders from the water. Since the basic radial resonance of these cylinders occurs near 40 kilocycles, the low-frequency response of the hydrophone is relatively flat with frequency. Larger size ceramic cylinders operating in the radial, or circumferential, resonant mode can also be used as sonar projectors to produce an omnidirectional directivity pattern in the plane of the diameter. The pattern is a plane containing the long axis of the projector is a function of its height.

Characteristics Can Be Varied

The pertinent characteristics of a transducer, such as resonant frequency, efficiency, voltage response, directivity pattern, power-handling capacity, and impedance, are controlled to a large measure by the type, shape, size, and mounting of the transducer active elements. The half-wavelength longitudinal (length equals a half-wavelength in the material) and the one-wavelength thin-walled cylinder (circumference equals a wavelength in the material) are the basic types of elements used in sonar transducers.

Magnetostriction, associated with ferromagnetic metals, iron, nickel, and cobalt, and alloys of these metals, refers to the change in dimensions of these materials when placed in a magnetic field. It also applies to the inverse effect of change in magnetization when the dimensions are changed by an external force. The direct magnetostrictive phenomenon is known as the Joule effect. The inverse magnetostrictive effect is referred to as the Villari effect.

A magnetostrictive element consists of a laminated core structure or toroidally wound cylinder with a magnetizing element and electrical winding. A magnetic bias is required in order to prevent contraction on both positive and negative cycles of the sine wave and vibration at twice the applied frequency.

How the Effect Is Used

A magnetostrictive nonresonant radial-mode hydrophone element used with submarine sonar equipment consists of a nickel alloy tube fitted with a bar magnet to produce a permanent magnetic field in a toroidal electrical winding. This is shown at D in the illustration, Typical Transducers. The hydrophone has a diameter of 2 inches and a length of about 3 feet and is mounted horizontally topside on a submarine. When sound energy strikes the hydrophone, the strain causes a change in magnetization which induces a voltage in the winding. The acoustic energy is thus converted into electrical signals and these, in turn, are amplified to indicate the presence of a target.

Another transducer, used in sonar communications equipment, is a cylindrical resonant magnetostrictive transducer, indicated as E in the illustration. It consists of a toroidal coil wound on a core of two identical Permendur scrolls which operate at remanence (the residual magnetization of a ferromagnetic substance subjected to a hysteresis cycle when the magnetizing force is reduced to zero) and have a nominal resonant frequency of 8.5 kc. The scrolls expand and contract diametrically at the exciting frequency.

An interesting magnetostrictive element for sonar application is the mass-loaded ring vibrator, shown below. The fundamental resonant frequency of a ring vibrator is proportional to the ratio of the stiffness to the mass and, therefore, to its average diameter. Increasing the radial thickness of the ring increases its mass but also increases its stiffness in approximately the same ratio so that its fundamental radial frequency changes very little.

Rings Have Large Diameters

Because of this, rings which are resonant in the lower portion of the audio frequency range are very large in diameter. A structure of a given size can be made to resonate at a much lower frequency than the fundamental resonance of an equivalent ring by increasing the mass of the ring and decreasing its effective stiffness. In the element shown below, the size of the mass-loads can be modified to alter the resonant frequency of the ring.

Magnetostrictive transducers have certain basic limitations which include the magnetostrictive effect of the core material, the strain level that can be tolerated, the dissipation of heat generated in the core, and the geometry of the elements. These place a limit on performance and operational characteristics.

The efficiency of these transducers may be as high as 80 percent at low levels but usually falls considerably below 40 per cent under high-power conditions. They are characterized by rugged construction, relatively high weight, high Q, low driving impedance, and narrow band-width. The Q of an unloaded transducer may be several hundred. However, when the transducer is water loaded, the Q will vary usually between 5 and 40, with the usual value falling in the region of 10 to 15.

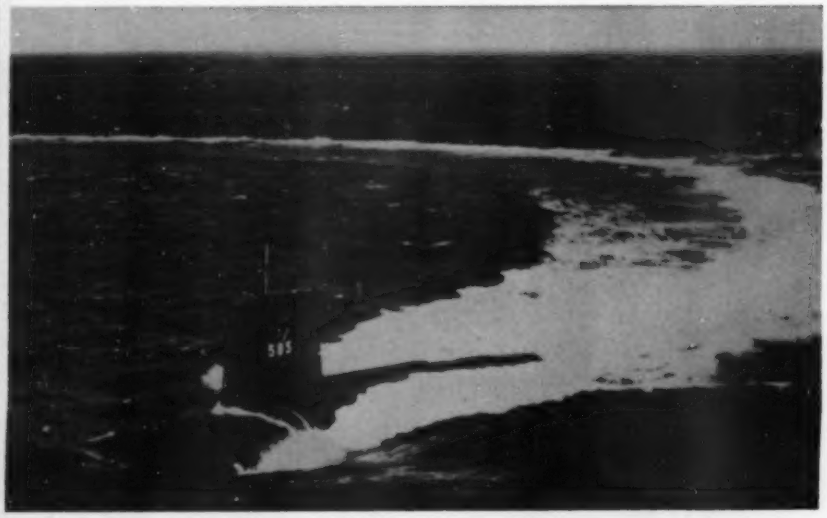
Piezoelectric effects were first demonstrated by Jacques and Pierre Curie after they had discovered that certain crystals became electrically polarized when compressed in a particular direction. Little advancement was made from 1880 until World War I when the submarine menace resulted in the first quartz electro-acoustic transducer.

Crystal Growing Helped

Following World War I, the piezoelectric field was relatively neglected until the early 1930's when interest was renewed in the commercial application of piezoelectric crystals such as Rochelle salt (sodium potassium tartrate). Interest mounted rapidly. Several hundred natural and synthetic crystals were found to have piezoelectric properties. A major contribution to the transducer art during World War II was the growing of ammonium dihydrogen phosphate (ADP) crystals, widely used in sonar transducer construction.

Only Rochelle salt, lithium sulfate, and ammonium dihydrogen phosphate are used to any extent in sonar work. The application of Rochelle salt is very limited because of its water solubility and wide variation of electrical characteristics with temperature. Rochelle salt has a piezoelectric activity about a thousand times that of quartz, but unfortunately this activity dwindles rapidly at temperatures above 45° Centigrade and the crystal disintegrates above 55° C. Lithium sulfate is used in thickness and volume-expander plates. It is particularly well suited for use in wide-frequency band omnidirectional hydrophones.

The majority of crystal sonar transducers, particularly units for high-power operation, use ADP elements. These crystals provide high electromechanical coupling. In addition, they are linear, reversible, extremely stable with temperature and exhibit no hysteresis effects. ADP crystals are stable up to 100° C and do not dehydrate since they contain no water of crystallization. At normal operating temperatures, ADP crystals have a higher electromechanical coupling coefficient than any other available nonferroelectric crystal.



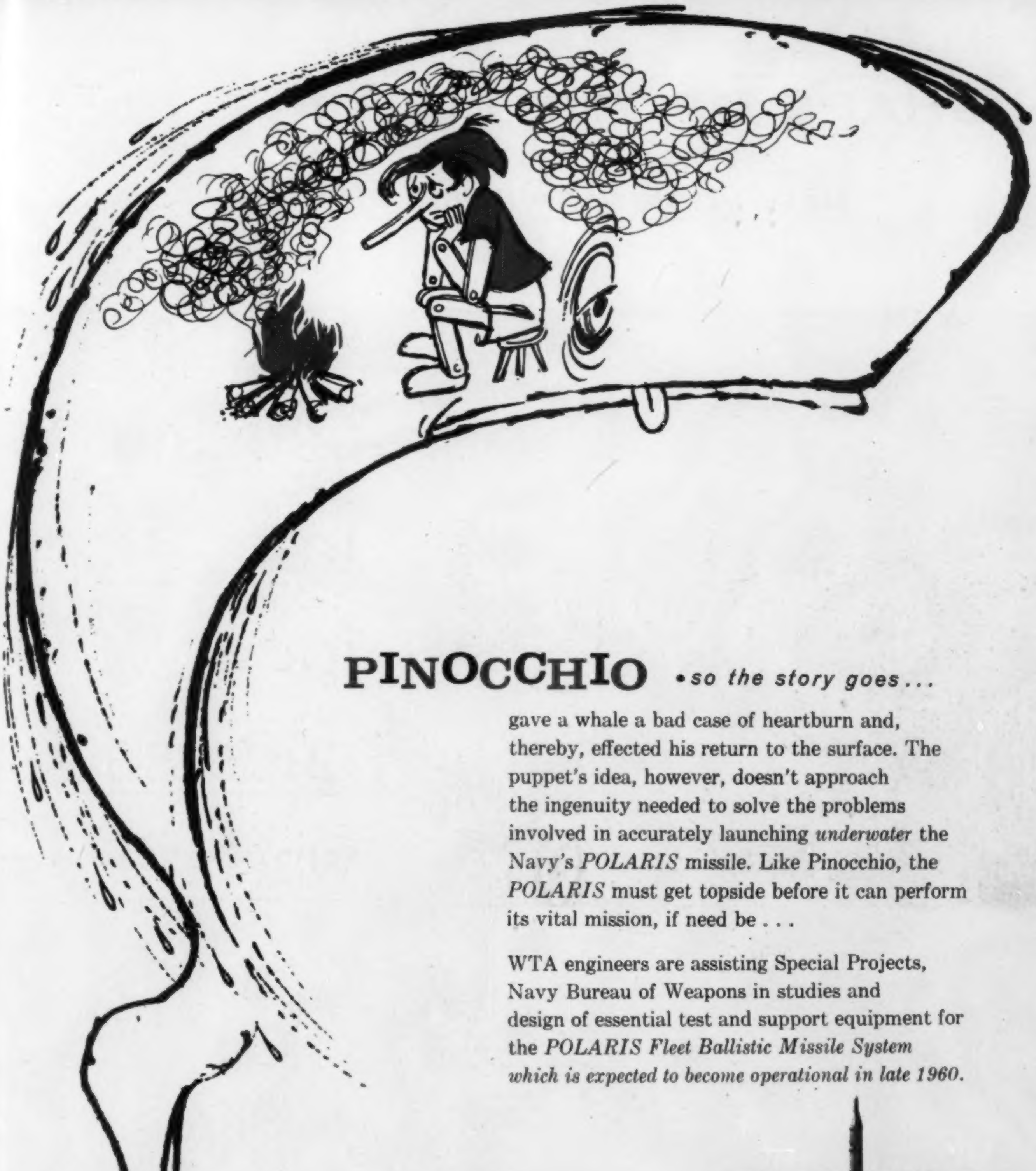
electro-acoustic transducer for undersea warfare

By Dr. Leon W. Camp
Director, Department of Applied Research
Bendix-Pacific Division,
Bendix Aviation Corporation

Transducers may be classified as to purpose, frequency, principle of conversion, bandwidth, etc. Operation at frequencies much above 50 KC is to achieve high resolution at short range, while operation below 10 KC is commonly used to get long ranges with high power output. To mention types in wide use according to principle of power conversion, transducers may be piezoelectric, electrostrictive, magnetostrictive, electromagnetic, variable reluctance, etc.

Piezoelectric and electrostrictive transducers consist of discs, bars, and cylinders, whose dimensions change with the change of an imposed electric field. Magnetostrictive transducers are of somewhat similar shapes whose dimensions change when an imposed magnetic field changes. Used as broadband hydrophones, these transducers may be small compared with the wavelength of sound in the active material, but when used as resonant systems for efficient power conversion, some dimension of the transducer must exceed a quarter wave in length. For example, at 1000 cycles, a resonant magnetostrictive cylinder will be about 15 feet in circumference. This requirement results from the fact that the cylinder develops sound by vibrating in its fundamental radial mode. Since the power handling capacity of these materials per pound is inversely proportional to the frequency of operation, there is a lower limit to the frequency at which these are practical.

Electromagnetic and variable reluctance transducers have an advantage in being lumped parameter systems.



PINOCCHIO •*so the story goes . . .*

gave a whale a bad case of heartburn and, thereby, effected his return to the surface. The puppet's idea, however, doesn't approach the ingenuity needed to solve the problems involved in accurately launching *underwater* the Navy's *POLARIS* missile. Like Pinocchio, the *POLARIS* must get topside before it can perform its vital mission, if need be . . .

WTA engineers are assisting Special Projects, Navy Bureau of Weapons in studies and design of essential test and support equipment for the *POLARIS Fleet Ballistic Missile System which is expected to become operational in late 1960.*

research
development
design
prototypes
testing
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W T A

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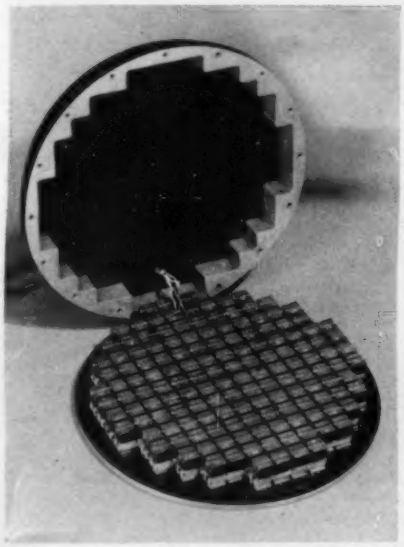


Transducer using magneto-striction elements

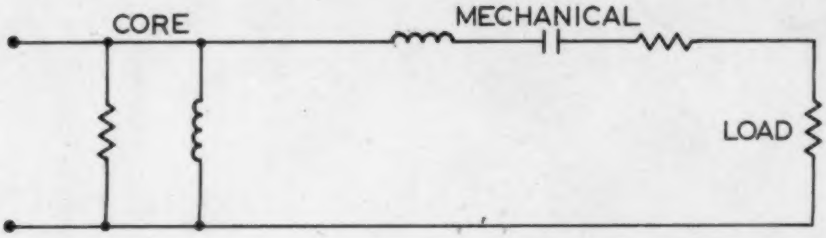


FIGURE 2.

EQUIVALENT CIRCUIT OF A MAGNETOSTRICTIVE TRANSDUCER.

That is, mass may be considered concentrated at a point and the spring may be massless. This makes a simple loaded spring system, allowing great flexibility in size and weight. Therefore, it may become necessary in the very low frequencies to develop projectors of these types. The variable reluctance transducer is activated by the interaction between moving iron mechanisms and the magnetic field. Electromagnetic transducers are activated by the interaction between a current carrying conductor and a magnetic field.

A rough problem for the systems engineers who are not transducer specialists, is that of finding up-to-date information on the construction and performance of underwater transducers. There are a number of good references for the study of performance characteristics which are common to all types of electro-acoustic conversion systems. The engineer with a good understanding of the equivalent electrical circuit clarifying the impedance behavior as a function of load and frequency has solved most of his problems as far as use is concerned. In addition, he should know how the geometry of a transducer—and this is independent of the conversation mechanism—is related to the geometry of the sound field.

To illustrate these features, Figure 1 shows the inside workings of a 50 KC magnetostrictive transducer. The components shown are longitudinal magnetostrictive vibrators which drive through a rubber diaphragm. Figure 2 is the equivalent circuit for a magnetostrictive transducer, and Figure 3 is the corresponding input impedance locus with frequency as the parameter. Figure 4 is a polar plot of the sound pressure developed in the medium by the transducer of Figure 1. The entire pressure pattern could be fairly well described by a surface generated by rotating this curve about the zero axis. To those not acquainted with these measurement techniques, the plot is normalized to unity on the zero axis and the length of the polar coordinate at any other angle gives a comparative value of the sound pressure at a fixed distance at that angle. This transducer is a plane array having a diameter of about 7 wavelengths as measured in the medium.

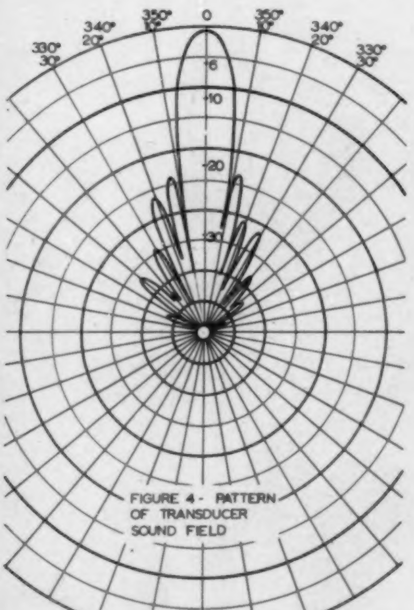


FIGURE 4 - PATTERN OF TRANSDUCER SOUND FIELD

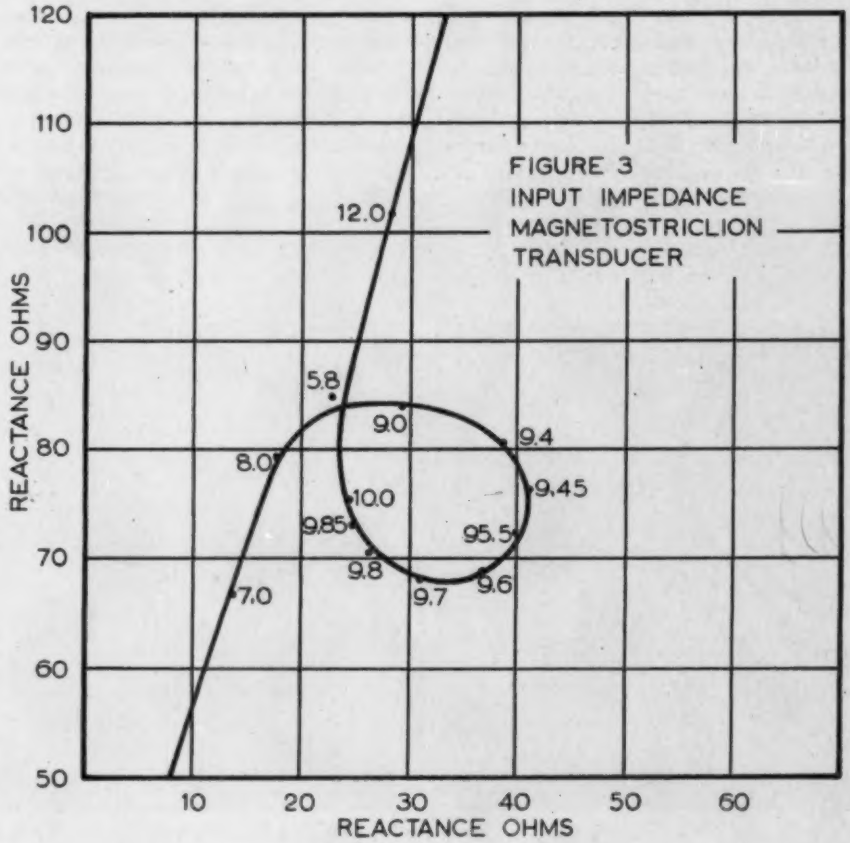
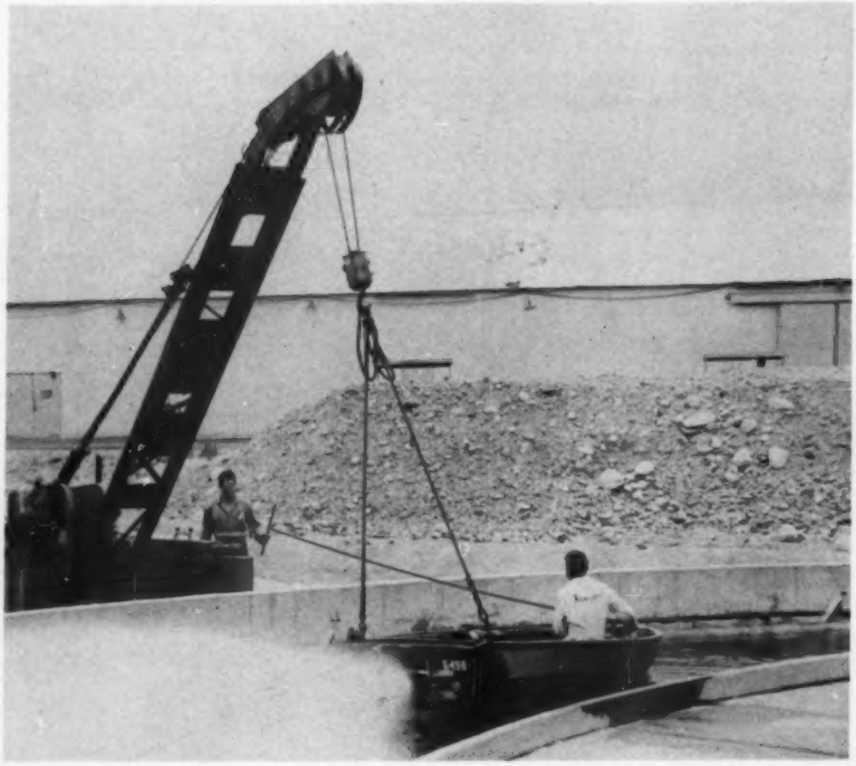


FIGURE 3
INPUT IMPEDANCE
MAGNETOSTRICLION
TRANSDUCER



ASW and undersea research at aerojet-general corporation

A West Coast Staff Report

AZUSA—Anti-Submarine warfare, for all its recognized importance, does not have the aura of glamour associated with space programs nor has it been able to arouse public opinion like the Sputnik. Even though it is recognized that three-fourths of the earth's surface is navigable water and that the Soviets have the lárgest submarine fleet in the world, anti-submarine warfare, because of many factors, is still viewed much like Mark Twain's often quoted maxim on the state of the weather. However when UE editors visited the West Coast recently, they found that this axiom is not true at Aerojet-General Corporation.

Aerojet's Antj-Submarine Warfare (ASW) Division, directed by Calvin A. Gongwer, works in close coordination with the United States Navy and is doing something about the situation. The division is working on a multi-million dollar Navy contract for the design, development and production of a high-speed ASW torpedo of radical design. Besides the torpedo itself, handling, launching, and fire control equipment as well as special component parts are also being devised for this complete torpedo weapon sys-

McRoberts

Gongwer

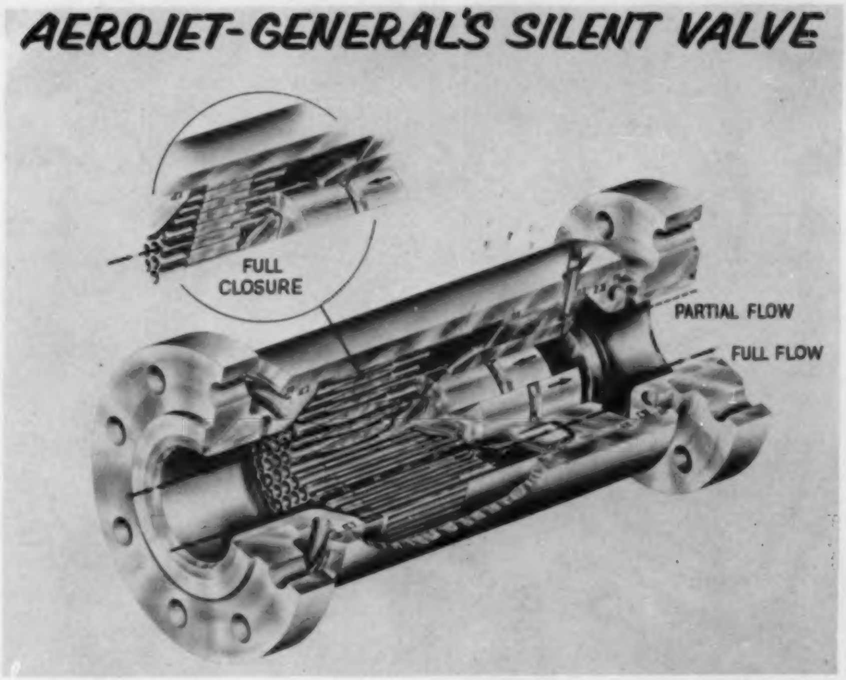
Walcott

tem. This work is under the management of George M. McRoberts.

The division is investigating and working in the entire spectrum of ASW and its allied fields. Its staff is interested in all types of undersea weapon systems including rockets, torpedoes, and other ordnance launched from submarines, aircraft, or special platforms. Liquid and solid propellant propulsion systems, high-speed submerged bodies, towed underwater vehicles, mine sweeping devices, and applied research in wave and sound phenomena are some of the programs under surveillance.

Dr. Fred J. Walcott, Chief Engineer of the Research and Development Department, and his staff have in the hardware stages such developments as the *Silent Valve, Hydroduct, Hydrocket, MiniSub,* and swimmer propulsion units. The throttling *Silent Valve* virtually eliminates aeration, cavitation, vibration, and the resultant noise associated with these physical phenomena. It is adaptable for both shipboard and shore installations. The *Hydroduct* is a water ram-jet power plant which uses sea water as a source of steam and can be employed in underwater weapons. The special, nongassing, solid propellant Alclo is used so that the water jet is 100 per cent condensable. Very high underwater speeds have been attained with this device.

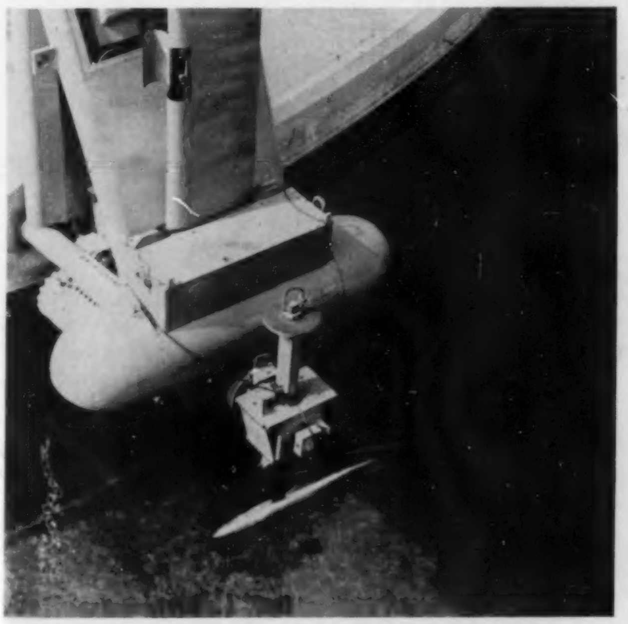
The *Hydrocket* is a water jet propulsion system used to power surface craft and eventually hydro-foil boats at high speeds. The system uses a conventional marine engine as its source of power. The *MiniSub* is a two-man, free-flooding submarine that could be employed by frogmen or operated as



a battery powered, remote-controlled drone. The swimmer propulsion units come in a variety of sizes, ranging from a one man bicycle-like unit to an aqua sled capable of carrying several hundred pounds of military explosives. The division also recently completed investigating the utility and feasibility of an underwater cargo vessel on a working study contract with the U.S. Maritime Administration, U.S. Department of Commerce.

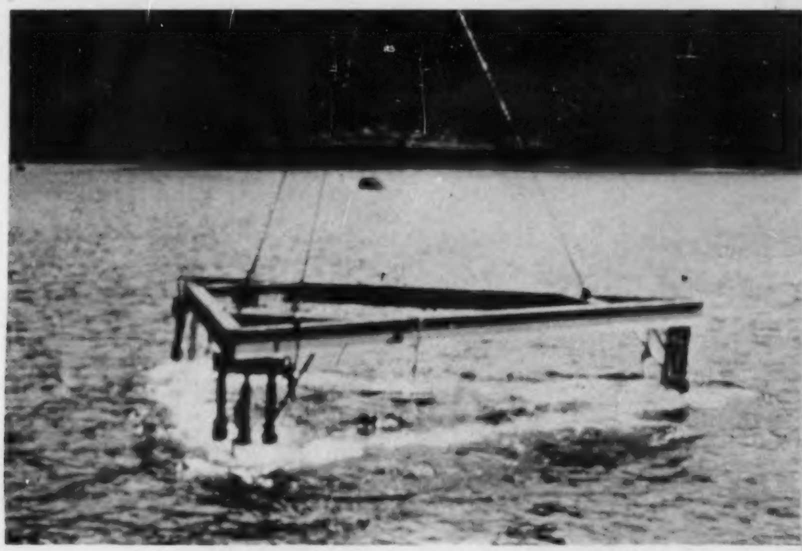
The ASW Division in Azusa, California is working closely with other Aerojet divisions in exploring every aspect of this liquid medium. Aerojet's Atlantic Division located in Frederick, Maryland and managed by Dr. John V. Atanasoff, is actively engaged in the field of underwater acoustic communications, detection, and identification. Dr. Atanasoff is a recognized authority in acoustics, theoretical and experimental physics, and engineering.

These are some of Aerojet's present programs, but what of future undertakings? According to Arlie G. Capps, head of the ASW Division's "blue water" planning and coordination for future projects, the problem is looked at from both a long and short range view point. The resulting programs and goals are selected by Aerojet's management after a thorough evaluation of the Navy's needs and the company's ability to perform in those areas.



Advanced hydrodynamics research at Aerojet's Azusa facility

test bed for polaris



By Commodore A. D. Hunter
(CEC USN Ret.)

Missile support activities have put civil engineers and construction contractors into some odd places—but probably none has been so odd as a point in the open ocean, some 60 miles off the coast of southern California.

Here, off the shore of tiny, bleak San Clemente Island, Navy missilemen handed out this job:

In very deep water, built a circular concrete launching pad about 10 ft thick, and 30 ft in diameter, embedded in the ocean bottom, to contain more than 235 cubic yards of concrete (about 500 tons), and to be equipped with various mountings and accessories. And, do this job in exactly 23 days of construction time, after less than two months of surveys and design, despite the danger of fog, high winds and "Santa Ana" conditions (where winds shift radically, and within a few hours can kick up a hurricane-sized storm).

The reason: This was the site selected for testing prototypes of the Navy's solid-fueled POLARIS missile. It had to be completed in time to coincide with production of the prototypes and testing apparatus, and approximate as nearly as possible actual conditions the missile would encounter when fired from a submarine.

It can now be revealed that the job was done in the time allowed. The work was actually completed in the Fall of 1957, but has remained under security wraps until now. It took the cooperation of the Navy's Bureau of Yards and Docks; a private consulting engineer firm; a four-contractor construction combine; divers; a closed-circuit television hookup; clever construction techniques—and a lot of luck.

• *Design starts*—San Clemente Island—a Naval testing station which is distinguished principally by a cluster of a half-dozen trees known to personnel as the "San Clemente National Forest"—had certain advantages for what the Navy had in mind for its POLARIS tests. There is little rainfall, the weather is generally good (except for the aforementioned "Santa Ana" conditions), and security is an easy problem.

As officer-in-charge of the project for the Navy Civil Engineer Corps, I was much concerned that the design we finally settled on would be a feasible one, in spite of the possibilities of interruption by weather. To insure that we obtained the best possible thinking on the problem—both from the theoretical and the practical sides—we did something unusual in ordinary construction practice: We brought the engineer and the contractor into the picture simultaneously, and from the very beginning.

Thus we had the advantage of the engineering knowledge of the Newark, N.J. consulting firm of Porter, Urquhart, McCreary and O'Brien; the practical know-how of a four-contractor combine known as CHAD-JV (Cox Brothers, Haddock Engineers, The Arundel Corp., and L. E. Dixon Co.); plus the experience and knowledge of the Bureau of Yards and Docks itself.

With this team working smoothly from its inception, the schedule went this way:

On October 1, 1957, a month of field work—consisting of oceanographic studies and hydrographic surveys—was completed, and the exact site was selected.

On October 4, 1957, detailed design was started.

On October 15, 1957, the contractor was given notice to proceed.

On November 18, 1957, final design was completed.

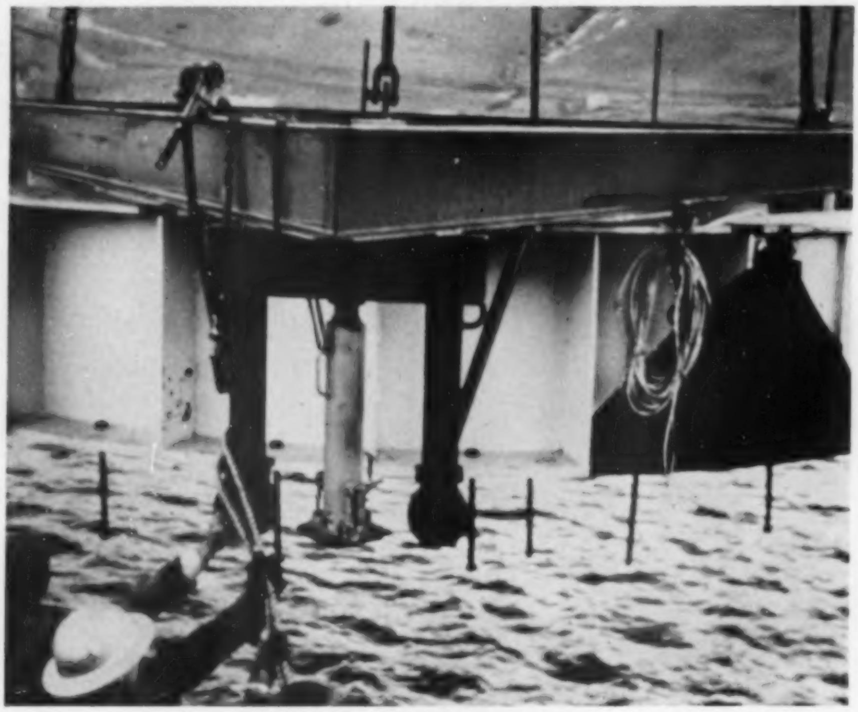
On November 23, 1957, 57 tons of steel foundation forms, base ring and levelling frame had been completed as to fabrication, on the island.

On November 26, 1957, actual construction at the open-sea site began.

On December 19, 1957, underwater construction was completed.

In March, 1958, Navy missilemen fired—successfully—the first POLARIS prototype.

• *How it was done*—The foundation form was actually an open, circular steel box, with relatively sharp cutting edges on its bottom side. It would be barged out to the site from the mainland 60 miles away, lowered until its cutting edges rested on the bottom, then sunk into the sand to a depth of 10 ft, by use of jets of water and air, previously placed along the cutting edge, to displace the bottom sand. The material displaced in this manner was to be raised to the surface for disposal by what construction men call an "airlift"—pushed up through pipes by air pressure.



Close-up of caisson before lowering

The same "airlift" method was then planned for use to complete excavation of the area within the big steel form, clearing the way for placement of concrete poured through pipes. Divers—aided by surface operators who would view the scene through a closed-circuit television hookup—would direct the underwater operations.

• *And so to work*—With all the planning done, the steel forms were loaded on a crane-equipped barge, and on November 26 all was in readiness for a start. As could almost be predicted, our worst fears were immediately realized: A "Santa Ana" blew up a storm that carried wind gusts up to 75 miles an hour. But we were in luck, anyway. By the next day, the winds had subsided and the barge was towed safely to the site, and made fast to a derrick barge. There was a further—fortunately temporary—delay, when fog obstructed the line of sight of positioning transits located ashore (the pad had to be placed with considerable accuracy because of testing requirements).

Divers were sent down, and four positioning points—steel pipes—were set in the ocean bottom so that the divers could align the form visually as it was lowered. They used, in addition, an improvised "plumb bob," consisting of a heavy, pointed steel weight, suspended by a piano wire from the floating crane.

With the big form seated, another problem came up. As mentioned, it had been intended to sink the form by a combination of jets and airlift excavation. But we were worried that the jets might blow the sand out from under the form unevenly, so that our final platform would not be level.

To solve this, it was decided to use the airlift only—and that had to be modified. The 14-inch pipe used to suck up the sand created such tremendous suction that the divers could not get close enough to it to guide it near the cutting edges of the form. A 6-inch pipe finally was built so that the divers could handle it, and a bundle of old steel rails was added to the weight of the form for better pressure. With this arrangement, the form was sunk to proper location and level in a day and a half.

This done, the launcher base ring and the triangular levelling frame were lowered and secured to the form. That is a simple statement—but it was no simple operation. At each corner, the levelling frame had two legs on wheels, enabling it to ride on top of the form and be rotated to the prescribed position, horizontally. Then vertical adjustment was made by 20-ton jacks installed between each point of the levelling-frame triangle and the top of the form.

Working under the pressure of more than a hundred feet of ocean water, the divers made the last adjustments to bring the ring to its final position, in a complex maneuver that was checked from the shore by the use of transits and the plumb-bob mentioned previously. A special problem was that the water depth was so great that divers could work only 50 minutes at a time—and could make only one such dive in 24 hours.

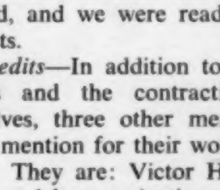
• *Concrete goes in*—Next came the final step—placing of concrete. Plans called for placing the aggregate (stone and gravel) in the form immediately after setting the base ring. Cement was then added, in a water solution, by pressure pumping from the surface. Rough seas delayed arrival of the aggregate barge, and a precious half-day of time was lost. It was not possible to observe the aggregate placing directly, since the placing of the tons of material so muddied the water that the divers could not see. But—despite our anxiety—a check afterward revealed that the contractor's skillful handling had not disturbed the positioning of the steel work.

Concrete was formed in two stages—the first being a three-foot depth that would form a seal, the second being the remaining 10 ft (approx.) needed to complete the job. Thus, a first pour of 77 cubic yards was made and allowed to harden overnight, before the final pour was completed.

After three months of continuous effort by all concerned, the underwater portion of the unprecedented "POP-UP" project went from conception to finish. In the succeeding weeks, the attendant supporting features of roads, communications, cameras, missile fall-back net, etc., were installed, and we were ready for the first tests.

• *Credits*—In addition to the consultants and the contracting firms themselves, three other men deserve special mention for their work on this project. They are: Victor Hertzlet of the Arundel organization and Les Miller of Cox Brothers, who were "lent" to the advisory team at the beginning, and stayed with the job to its completion—many of the features of the design were the result of their suggestions; and Lt. Cmdr. Robert E. Dickman, then of the Navy District Public Works Office, Eleventh Naval District, San Diego, who served as Resident Officer in Charge of Construction for the duration of the work.

Feature articles in this issue are not printed in their entirety. Ed.



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